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NOTES ON THE
USE OF MACHINE GUNS
IN TRENCH WARFARE

AND ON THE

TRAINING OF MACHINE GUN UNITS
COMPILED FROM FOREIGN REPORTS

ARMY WAR COLLEGE

MARCH, 1917



WASHINGTON
GOVERNMENT PRINTING OFFICE
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WAR DEPARTMENT,
WASHINGTON, May 7, 1917.

The following notes on the use of machine guns in trench warfare
and on the training of machine-gun units are published for the
information and guidance of all concerned.

[2593173, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

H. L. SCOTT,
Major General, Chief of Staff.

OFFICIAL:

H. P. McCAIN,
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MACHINE GUNS IN TRENCH WARFARE.

In trench warfare as it exists in Europe, automatic machine rifles, popularly called machine guns, find their greatest use. Besides the trench, the essential elements of a trench line consist of a depth of wire and a front of machine guns.

The tremendous stopping power of machine guns enable them to replace a large number of riflemen along this line, reducing to a minimum the men employed in actual defense, thereby leaving a large part of the force in reserve for use in the counter attack, or for the assumption of the offensive at another part of the line. Their use also reduces the daily wastage due to sickness, and prevents the offensive spirit of the Infantry from becoming impaired.

Opposing belligerents in the present European struggle soon found it necessary to greatly increase the ratio of the number of machine guns per 1,000 Infantry rifles to 8, and in some areas to even larger figures. This ratio would give about 12 machine guns to one of our maximum strength Infantry regiments, and this number may be assumed as the minimum that would be required to properly defend the front that would be assigned to an Infantry regiment.

Comparison table of automatic machine rifles in most general use in Europe.

Name.	Gun weight in pounds.	Tripod weight in pounds.	Number cartridges in belts or strip, etc.	Operating force.	Cooling.	Rate of fire, rounds per minute.	Vertical swing.	Horizontal swing.
Maxim.....	160	48	250	Explosion and fusee spring.	Water.....	450 to 500	238-90	360
Vickers' light....	138 $\frac{1}{2}$	48	250	.....do.....	.....do.....	500	238-98	360
Colt.....	35	58	250	Gas and spring	Air.....	400	70	360
Hotchkiss (portable).	30	3 $\frac{1}{2}$	30	.....do.....	Air or change barrel.	250 to 400	.....	.....
Lewis.....	425 $\frac{1}{2}$	3 $\frac{1}{2}$	47	.....do.....	Air with aluminum radiator.	400	.....	.....

¹ Jacket filled with water.

² Depending upon adjustment of tripod.

³ Folding.

⁴ With magazine filled, 30 pounds.

TYPES OF AUTOMATIC MACHINE RIFLES.—The term "machine gun" is popularly applied to all rifles of this character. Some foreign authorities, however, are careful to apply the name "machine gun" to automatic machine rifles of the Maxim, Vickers, and Colt types only, calling those of the Lewis, Light Hotchkiss, and Madsen types "Light automatic weapons," for the reason that the latter are a cross between the machine gun proper and the automatic rifle. The term "automatic rifle" implies a weapon which can replace the ordinary magazine rifle in the hands of the individual soldier.

The powers and limitations of these two classes of automatic machine rifles have been carefully studied and each is used for the work to which it is best suited. The machine gun, or heavier type, is used where long-sustained fire of any kind is necessary, as for:

- (a) Creating bands, or belts, of fire across the front of a defensive position.
- (b) Guarding the flanks of an attack by covering areas of ground with fire.
- (c) Long range covering fire.
- (d) Indirect fire, etc.

The lighter, or Lewis gun type, has generally been assigned to Infantry battalions and is considered ideal for supplementing the fire power of riflemen, assisting them to gain fire superiority and closely supporting them on all occasions in either attack or defense.

The Lewis gun type is the first to go forward in an attack and the last to be brought away in a retirement. This type enables fewer of the machine-gun type to be placed in the front line of an entrenched position, reduces the number of Infantry in the front-line trenches, and enables positions won in an attack to be more quickly organized.

THE UNITED STATES AUTOMATIC MACHINE RIFLE.—The Benet-Mercie machine rifle, model of 1909, is an extremely light weapon. The gun alone weighs 30 pounds, or just a few pounds more than the Lewis gun, and it can be used in the front-line trenches or to accompany an Infantry line with the same facility that the Lewis gun is used for these purposes in Europe at present. The Ordnance Department has recently modified a Vickers tripod for use with this gun, which will enable it to be used in the support trenches and other positions in rear, as are the Maxim, Vickers, and Colt machine guns abroad. The tripod weighs 45 pounds and can easily be carried by one man in a creeping or crawling position over all kinds of ground.

When mounted on this tripod, the Benet-Mercie machine rifle, model of 1909, can, upon occasion, deliver overhead fire, long range, indirect, and searching fire, traversing fire, etc.

In other words, our automatic machine rifle can, upon occasion, play the rôles of the six types or two classes of machine rifles in use abroad.

The gun has a case for protection against dirt and weather, which weighs about 16 pounds, so that the gun in its case weighing about 46 pounds, and the modified tripod weighing 45 pounds, can each be carried by a single man.

As the War Department has recently adopted the Vickers as the heavy type machine gun for the United States Army, it is unlikely that the Benet-Mercie machine rifle will be called upon to do any work except that to which it is best suited.

CHARACTERISTICS OF MACHINE GUNS.

(a) **Their power is limited to fire action.**—Machine guns by fire action alone can pave the way for an attack or drive back a hostile assault, but they can not gain ground. The latter is almost exclusively the rôle of Infantry, which is capable of crossing all obstacles. Whenever, therefore, fire action alone is needed, machine guns can be advantageously employed in preference to Infantry, the latter being reserved for fire action combined with movement.

(b) **Nature of fire.**—Machine gun fire is concentrated; therefore it will be most effective against a narrow and deep target. As Infantry normally advances in extended order, the best means of obtaining the above-mentioned target is by the use of oblique or enfiladé fire. For this reason flanking fire should be the rule.

Frontal fire should only be used against troops in close formations and against approaches, such as roads, bridges, defiles, communication trenches, etc.; that is to say, against places where the enemy is compelled to take up dense formations on a narrow front. The traversing arrangement allows the gun to be turned through a considerable angle without moving the tripod, and with little exposure.

(c) **Invisibility.**—Owing to its small frontage it is easier to find a concealed position for a machine gun than for an equivalent number of riflemen. Hence, the possibilities of surprise effect are very great. Surprise is essential for the successful handling of machine guns. Flanking fire and surprise effect should always be sought for.

(d) **Mobility.**—The machine gun can go where a man can go on foot.

EMPLOYMENT.

The general principles governing the employment of machine guns are exactly the same in either open fighting or trench warfare, but to secure maximum results from the guns on all occasions the best method of applying these general principles to the peculiar conditions of the present war must be studied.

The machine gun is a weapon of opportunity, but the machine-gun commander must not passively await the opportunity. He must keep in close touch with the situation and look for or make an opportunity for the successful employment of his guns. The machine-gun officer must, therefore, be alert and handle his guns with boldness and cunning. The gunners must be determined, steady, and full of resource and initiative.

COOPERATION.—Cooperation is essential, not only between the machine guns of a single organization, but between those and the guns of adjacent units. Arrangements must be made for cross fire along the entire front, and for covering spaces not reached, or reached with difficulty, by artillery fire.

OPENING FIRE.—The general rule that machine guns must not open fire until a good target presents itself must not be carried to extremes, otherwise opportunities for the infliction of both moral and actual damage upon the enemy may be lost. The effect likely to be produced upon the enemy is the guiding principle which justifies the opening of fire. It is often impossible to see anything of the enemy, and likely positions for him to occupy must be looked for and these searched with fire, if necessary.

Well-concealed machine guns may often direct their fire against: (1) Windows, doors, and roofs of houses thought to be occupied; (2) areas of standing crops and brush; (3) open spaces that small parties of the enemy are crossing; and (4) the enemy's firing line.

NECESSITY may require machine guns to open fire upon unsuitable targets to assist the advance of the infantry, or to open fire in self-defense.

SURPRISE EFFECT should always be the aim of the gun commander. Unless a surprise opening of fire is obtained, the gun detachment, and perhaps the gun itself, may be put out of action before any effect whatever has been obtained.

POST OF DETACHMENT.—As few men as possible should be around the gun. Those not actually necessary to work the gun should be engaged in the ammunition supply or under cover.

INTERVAL BETWEEN GUNS.—If liable to be subjected to artillery fire, the interval between machine guns should be such

that no two guns will be included in the burst of a single shrapnel. This interval should never be less than 20 yards. The gun positions should be such that the guns may give mutual support to one another by means of cross fire. Positions close to objects whose range is known to the enemy, or near prominent objects that will aid the enemy in finding their range, are to be avoided. A position in front of a dark background, or in ground covered with a suitable growth that will hinder observation, should be sought. During an advance or a retrograde movement the guns support each other by advancing or retiring alternately, as the case may be. When moving with infantry, the machine guns should mix with the infantry and try to disguise their identity as much as possible.

UNDER ARTILLERY FIRE.—Great care must be taken to prevent the machine guns from being located by the artillery. If guns are shelled, they must change position at once. A move of 50 yards will generally be sufficient. These alternative or secondary positions will always be selected in advance.

It may sometimes be desirable for the detachment to cease firing and to retire with the gun under cover until the shelling stops. If this is done, the hostile artillery may think the gun has been put out of action. When good targets present themselves, the machine guns may then open fire again from the same position.

AGAINST ARTILLERY.—The use of machine guns against artillery is exceptional. The following cases have been reported from abroad:

(a) A section of machine guns worked forward to a concealed position 900 yards from a field battery in action, and bringing oblique fire against the battery, completely silenced it.

(b) A field battery in action was taken in enfilade by a machine-gun section at 2,400 yards. The gunners fled and the battery was silenced.

Frontal fire against shielded artillery will produce moral effect, which should be considerable; it should also greatly interfere with the supply of ammunition to the guns.

CARE OF MACHINE GUNS.—Every lull in the firing should be taken advantage of to clean and oil the gun. Springs should be tested and the gun inspected many times daily to be sure that it is always ready to respond in any emergency. The ammunition must be kept clean. When not in use the gun and ammunition should be covered with waterproof covers to protect them from water, dust, and dirt.

CONSIDERATIONS GOVERNING THE PLACING AND USE OF MACHINE GUNS IN TRENCH WARFARE.—The answer to the question, "In what way must the machine guns at my disposal be placed and used to best prevent the enemy from capturing these trenches?" will decide in almost every case how the machine guns must be located, distributed, and used.

Unless the opposing trenches are so close together that a bombardment is impossible, an offensive with the object of breaking our line will always be preceded by an artillery preparation. The object of this bombardment will be to destroy the wire entanglements and other obstacles in front of our trenches, to destroy our trenches, dug-outs, artillery, machine guns, personnel, and strong points in the area to be attacked, and to prevent our reserves from being brought forward.

After what the enemy considers a suitable artillery preparation, his grenadiers, infantry, and machine guns will move forward to capture our trenches. If he has a superiority of artillery it must be expected that he will penetrate our line in places. But we must be prepared to receive him with several successive belts of machine-gun fire that will delay him and inflict such losses upon him that he will be forced to use up his reserves before gaining any substantial advantages. By this time our counterattack should be able to drive him back with heavy losses.

The duties of the machine guns of the defense may be enumerated to be:

- To replace as many riflemen as possible in the actual defense.
 - To prevent the enemy from leaving his trenches.
 - To sweep all ground between our trenches and those of the enemy.
 - To prevent the enemy entering our trenches.
 - To isolate portions of our trenches if captured.
 - To sweep communication trenches leading from our front trenches to our support trenches.
 - To sweep all ground between our support line and front line.
 - To provide emergency belts of fire from the rear to replace broken belts.
 - To engage enemy when concentrating for assault.
 - To sweep covered approaches to enemy's defensive line.
 - To engage enemy machine guns.
 - To sweep ground in rear of the enemy's lines.
 - To provide covering fire for counterattacks.
- These duties and the necessity for cooperation and coordination of effect require that all machine guns be under the direction of one officer. They also require guns to be distributed.

In or near the front line trenches.

In or near the support trenches.

In positions in rear along communicating trenches.

In strong places in rear.

In reserve.

The number of guns available will govern the decision as to whether machine guns can be placed in all of these positions at one time.

Reports from the present European war indicate that several successive lines of defence are not to be aimed at, but rather a defended area whose fortifications are laid out according to the nature of the ground, giving machine guns freedom of position that will not only reduce the chance of their being knocked out, but will also reduce to a minimum the number required to form any particular belt or band of fire.

Reports also indicate that machine-gun defence schemes must be divisional, in order to make these belts of fire continuous and to enable the construction of machine-gun fieldworks to go on without interruption. The scheme is worked out so as to hide the machine guns from enemy artillery and protect them from hostile bombers and snipers.

LOCATION AND DISTRIBUTION.—In trench warfare, for the reasons given above, machine guns are distributed singly along the front of the position and in the area to be defended. Some of them are placed in the firing trenches, some in emplacements between these trenches and the wire entanglements, and some behind the parados just in rear of the front-line trenches. The positions of those in the firing trenches themselves are generally in salients, reentrants, or bends in the trench line. Those in front of, or in rear of the trench line, are generally placed in front of or in rear of a traverse. All of these locations are positions where they can best cross their fire for mutual support and where they can best bring an enfilading fire against an advancing infantry line.

Emplacements in front of the firing line are made by digging narrow trenches of the same depth as the firing trench to the front, 15 or 20 feet, and then turning them to the right or left and widening them out to accommodate the guns and crews. The gun rests solidly on the ground at the end of this cul de sac which is sunk just low enough below the natural ground to conceal it when in position.

Some machine guns are placed along or near the line of the support trenches, a short distance in rear. If the shape of the ground permits, these are so placed as to fire over the heads of troops in

the firing trenches, to aid in repelling an attack, also to bring fire on the first-line trenches in case they should be occupied by the enemy.

Some of the machine guns are emplaced along the communicating trenches and some around a strong point, 200 or 300 yards in rear of the front-line trenches, in such a way as to stop the enemy should he be able to capture the first line and support trenches, and to hold him until a counterattack can be delivered.

The remainder of the machine guns are held in reserve, to replace casualties, or for use where the commander may decide and for instructional purposes. Plates 1, 2, 3, and 4 show the location of machine-gun emplacements and the methods of obtaining enfilade, covering, and cross-fire along three different fronts in Europe. Plates 5 and 6 show some details of the position shown in Plate 1.

EMPLACEMENTS.—In positions in the line where one can be heavily bombarded, machine guns, or at any rate some of them, should be kept under cover day and night, but in those portions of the line where the enemy is so close that a bombardment is impossible and our only fear is a sudden rush, machine guns should be mounted in position ready loaded, always at night, and also during the daytime when the entanglements will not give sufficient time for them to get ready.

The number of emplacements constructed must generally be greater than the number of machine guns assigned to the protected area, for guns which come under artillery fire must have an alternative or secondary position and there must be emplacements for the machine guns in reserve and there must also be emplacements in reserve to take the place of those destroyed by the artillery bombardment.

The enemy's bombardment of our front line must cease when his infantry arrives within about 200 yards of it, but it will increase in intensity against the trenches in rear, in order to prevent the infantry and machine guns in those trenches from participating in the defense. It follows, therefore, that our machine guns must be numerous enough along the front line and sufficiently strongly emplaced, so that enough of them will survive the bombardment and appear as soon as the artillery cone lifts and open fire on our wire entanglements and the ground in front of it.

Owing to the extent of front attacked and to the difficulty of artillery observation, it is unlikely that an entire front-line system of trenches and machine-gun emplacements will be entirely pulverized by any artillery bombardment. The experience in Europe has been that some machine guns and crews have always survived, ready

to emerge and open a flanking, annihilating fire against the enemy's advancing infantry and the more oblique has been this cross fire the greater has been its effect.

The emplacing of guns for cross fire, however, must not be carried to the extreme. While the front of each gun is supposed to be protected by the cross fire of its neighbor, if the neighbor should meet with mishap or should be under artillery fire and unable to perform its function, fire to the front must be arranged for by the gun itself.

Where opposing trenches are close together and machine guns would be subject to capture by raid if placed in the front-line trench or in front of it, this danger can be avoided by emplacing them behind the parados of the firing trench. This position will give a better field of fire, and, owing to the feeling of safety which this position inspires, the men will work their gun with more coolness and judgment than if the gun were sited in the parapet or in front of it.

Plate 12 shows such a gun position connected by an underground passage to an ordinary infantry dugout, situated under the parapet. In this dugout underground cover is provided for the machine gun, its crew, as well as for the infantry squad pertaining to that trench. The dugout is also connected with the firing trench. Should the infantry squad be driven from the firing trench, or should this trench be destroyed, they will take post behind the parados on the flanks of the machine gun.

Plates 7, 8, 9, 10, and 11 show some types of open and protected machine-gun emplacements that have been used in the present war. If time and materials are available, some of the emplacements and dugouts near the front line must be made strong enough to resist the heaviest bombardment.

It must be remembered that the stubborn defense of the front trenches will often depend on the machine guns, and that although the rifle garrison may sometimes be withdrawn to their bomb proofs and dugouts, the machine gunners must remain at their posts. Therefore, the machine guns and their personnel must have dugouts and emplacements that will survive the bombardment.

The general experience of the effect of intensive bombardment on front-line trenches, when well carried out, has been that large portions of the parapet have ceased to exist; and that unless machine-gun emplacements in the parapet are dug at ground level and covered by heavy beams, heavily supported, they will be destroyed at the same time. A system of strong dugouts behind the parados in which

most of the machine guns can be kept safely during bombardment, will make them available when the bombardment is over.

In connection with the emplacements there must be ample protection for look-out men, who are detailed to give the signal for the mounting of the machine guns as soon as the artillery cones lift. It is reported that concrete emplacements and dugouts have been constructed at many important points on the present trench line in Europe.

Dugouts can be made by tunneling deep down under the parapet or parados, or by building shelter in a traverse.

Plenty of earth, well supported by timber and inconspicuous from the front, is the aim in their construction. Machine-gun dugouts should be near the gun emplacements, and it seems to be the practice to build two dugouts for each gun. Into these are carried the gun, spare parts, and ammunition during a bombardment when the emplacements are too weak to remain in them.

Emplacements should be constructed to look like the remainder of the trench and loopholes should be masked.

The simplest form of emplacement is a semicircular pit about 2 feet deep with sand-bag revetment. Emplacements are numbered from right to left in any given section.

Plate 12 shows a simple type of machine-gun loophole.

Plate 13 is a type used for night firing.

The simplest form is an arrangement whereby a steel shield and one or more sandbags can be removed from the revetment.

The machine guns in the strong points should be emplaced to fire in all directions. The emplacement should be very strong, with dugouts, overhead cover, and ammunition depots, all protected by snipers and bombers, and the whole surrounded by wire.

DIMENSIONS OF EMPLACEMENTS, DUGOUTS, AND LOOPHOLES.—Dugouts and emplacements are made as small as possible. The least dimension for a dugout for 4 men will be found to be about 6 by 5 by 4 feet. Minimum dimensions of emplacements are about the same, though a minimum of 5 by 4 by 4 feet is reported to be in use for both of these in the present European trenches.

The firing platform must be from 18 to 24 inches below the height over which the gun is to fire.

The loophole is generally 9 inches high by a dimension determined by the thickness of the parapet and the number of degrees of traverse desired.

MATERIALS.—A loophole box is easily made of 2-inch plank. Sleepers of 6 by 4 inch material for roofing and upright posts of

7 by 4 inch dimensions will be found strong enough to use in emplacements and dugouts. Corrugated iron sheets may be used to cover the roof. Some nails will be needed, also sandbags and close mesh wire netting for revetting.

Protection from rifle fire, shrapnel, and splinters from shells, bombs, and small high explosive shell from field guns, will generally be obtained by a parapet of earth $6\frac{1}{2}$ or 7 feet thick. Open emplacements should have this thickness of earth in front of them. Covered emplacements will be splinter proof if there is 20 inches of earth on top.

AMMUNITION.—An ammunition chamber must be prepared in each emplacement. In this is kept sufficient ammunition for immediate needs, a box of spare parts for the gun, oil, and cleaning materials.

All alternative emplacements have these chambers fully equipped so that they may be occupied at a moment's notice if the regular emplacement has to be abandoned. Ammunition supply must be carefully thought out. Reserve ammunition in unopened boxes and arrangements for refilling empty strips or belts and making repairs are located, with spare gunners, at a central dugout. Arrangements must be made to keep ammunition clean and dry. It should be inspected daily.

RANGE CARDS.—Cards are prepared for each emplacement and alternative emplacement, giving reference point and ranges to all probable targets and to prominent objects. These are left in the emplacement day and night, whether occupied or not. Plate 14 shows a form used abroad.

GENERAL REMARKS.

To reduce losses during bombardments, when there is danger of a machine gun being struck, it is usual to dismount it, wrap in a waterproof covering, and remove it to a safe place, leaving the tripod in place so that the gun can be quickly mounted in case of emergency. If no safe place is available, the gun is put in the bottom of the trench, the waterproof covering preventing its becoming clogged if buried by shell fire. Gunners should not retire to the same dugout or to the same part of trench. After bombardment two men mount the gun, the remainder of the personnel remaining under cover, unless the signal of enemy attack is given, when, of course, no attention is paid to this precaution. As few men of the gun crew as possible, generally 3 or 4, remain in the front trenches, the others remain in dugouts and reserve trenches in rear.

One emplacement is usually reserved for each gun as a "Battle emplacement," to be used only in case of enemy attack. Alternative and dummy emplacements are used from day to day for firing at such targets as present themselves. A few rounds from these will deceive the enemy as to the location of best emplacements, as well as the number of guns along the line. Emplacements and dugouts must be kept in good repair. Sandbags, chicken wire, and stakes are freely used in repairs.

In each emplacement the limits that the machine gun can with safety be traversed without endangering friendly troops should be clearly marked by posts, stakes, or sandbags, arranged so as to make traversing beyond these limits impossible.

OVERHEAD FIRE.—Whenever machine guns are going to fire over our own trenches, the occupants of the trenches must be informed.

LAYING OUT TRENCHES.—When entrenchments are dug deliberately, they should be laid out with a view to defense by machine guns. The machine-gun positions should first be chosen and the trenches laid out accordingly, thus enabling the trenches to be held by machine guns, supported by a minimum number of riflemen.

POST OF MACHINE-GUN COMMANDER.—The commander must locate himself centrally so that messages may readily reach him, and so that he can coordinate the work of all the guns of his command according to the plan of the commander of the troops. He must have at hand orderlies and signal men well trained in maintaining communication with the different gun positions.

EQUALIZING DUTIES.—To give men and officers of machine-gun organizations sufficient rest, a regular roster should be kept. As only three or four men are needed with the gun in the front line at any one time, the remainder of the crew should be allowed to remain in reserve in the reserve trenches or reserve dugouts. This will enable men in the front line trenches to be relieved every 24 hours. Organizations should be relieved as often as possible.

PERISCOPES.—Periscopes should not be used from machine-gun position, but to one side of them.

ILLUMINANTS.—Each machine gun in the front line should have a Very pistol, or some other illuminant to show up enemy night attacks and enable fire to be directed on them.

SNIPERS AND BOMBERS.—When opposing trenches are close together, bombers and snipers should be detailed to protect the flanks of machine-gun positions.

Also during an attack, the machine guns will be worked to better advantage if a few men are assigned to their protection from bombing attacks of the enemy.

ENEMY MACHINE GUNS.—When contemplating an attack, if enemy machine guns are located, and they are not doing any material damage, it may be advisable to leave them alone, instead of firing at them and making them change their positions. Then, when our attack is launched, the guns may be in the same position and our guns may be able to keep them from firing on our troops.

OBSERVATION.—Officers, noncommissioned officers, and all men of machine-gun units must be well trained in the use of the telescope, both for observation of fire and in picking up the enemy's machine guns. This requires constant practice.

CONCEALMENT.—Concealment must be aimed at in every case. Emplacements are made to look like the surrounding ground, so as not to attract the attention of enemy observing parties. Saps leading to emplacements are covered with canvas, brushwood, straw, sandbags, etc., to prevent photographic location by aircraft. The coverings can be easily removed if necessary.

ORDERS.—Owing to the fact that the immediate gun detachments change each 24 hours and organizations are relieved from trench duty frequently, it has been found necessary in the present trench warfare in Europe to have the orders for each gun detachment posted in the gun position so mistakes will not occur.

These orders prescribe among other things:

1. That when detachments change, the piece shall be inspected that the points shown on the range card be pointed out carefully and that report be made whether the gun has been fired during the preceding relief; if so, at what target, and from which emplacement.
2. That fire is to be opened only by order of the gun commander, except in a sudden emergency.
3. That the gun, ammunition, and spare parts shall be cleaned and oiled daily.
4. Hours when gun will be mounted in emplacement.
5. Other rules necessary for the particular emplacement and the care of the gun.

USE OF MACHINE GUNS IN THE DEFENSE IN TRENCH WARFARE.—It has been previously stated that when machine guns are placed for the defense of an entrenched line, the guns of each section of the line must be arranged under the direction of one officer. This officer will be the machine-gun officer of a brigade, under the supervision of the division machine-gun

officer, for the reasons stated. Under his direction, areas to be covered are allotted to each machine gun. These areas should slightly overlap.

In allotting these areas, care must be taken that the whole of the area can actually be seen by the man firing the particular gun. The mere marking out of theoretical areas of fire on a map is not sufficient. It is the custom abroad to prepare a trench map showing the position of the machine guns and the areas covered by each.

Machine-gun officers of adjacent brigades must confer together as to the placing of their flank guns, in order to insure that all ground in front of the entrenched line can be and will be swept. The machine-gun officer also studies the enemy's advanced trenches and finds out those portions that can not be reached by our artillery, or that can be reached only with difficulty, and arranges his machine guns so as to bring enfilade or oblique fire upon them. Fulfilling all of these conditions his aim will be to locate his guns so as to create several successive belts of machine-gun fire and to place his machine guns so as to bring enfilade or oblique fire against the enemy's trenches, the ground over which the enemy must pass should he attack, and against our own front line trenches should the enemy succeed in entering them.

As previously stated, these objects will generally be achieved by placing the guns either in front of the trench, in a bend of the trench, in a salient, in a reentrant, or in or near support and communication trenches.

The machine guns should always, if possible, be covered from fire from the front, while themselves being able to sweep the front of the entrenched line with cross fire. The front of each gun is swept by the fire of its neighboring machine gun, but in cases of emergency, all guns must have arrangements for firing to their own front.

Some sandbags can be removed and the machine gun can be fired to the front through the loophole thus made, or the gun can be quickly removed from the tripod, if mounted, and fired over the parapet without it, or it may be fired from some other position previously selected.

DISTRIBUTION OF THE MACHINE GUNS.—The shape of the ground will determine the distribution of the machine guns to a great extent. As a general rule some of the machine guns will be placed in or near the front line of trenches, for if it is intended to defend the front line obstinately, the machine guns may just make the difference between success and failure. Some will usually be placed in or near the support trenches to prevent the further advance of the enemy should he be able to enter the front line trenches.

If the ground is favorable some will be placed in concealed positions in rear and arrangements made to fire over our trenches and sweep the ground in front of them, to fire through gaps in our line, to cover positions from which the enemy might prepare for an assault, to bring fire upon positions likely to be occupied by enemy machine guns, to assist our own troops to assault by protecting their flanks, and by overhead covering fire, and to use indirect fire against ground in rear of the enemy's lines.

Some will, if possible, be placed in strong points farther to the rear, that must hold out till a counterstroke can be delivered.

Any remaining guns are held in reserve to replace those disabled, to reinforce threatened points, and for instructional purposes.

If there are not enough machine guns for all of these positions at one time, emplacements should at least be prepared in all of them and arrangements made so that machine guns may be quickly placed in any of these emplacements, when required.

Arrangements are also made for rapid communication between all parts of the machine-gun defense area, and a quick ammunition supply system worked out.

The brigade machine-gun officer must know the brigade commander's plans and he must work out the whole machine-gun defense scheme, so as to coordinate the use of his guns with these plans. His post must be near that of the brigade commander, or in such a position that he can easily communicate with him.

USE OF MACHINE GUNS IN THE ATTACK.—It has been found that continuous trench service impairs the offensive spirit of troops; so now when an attack is contemplated, fresh troops, who have not recently served in the trenches, are brought forward to make it. These are selected troops of best training and highest morale. Aeroplane maps of the front to be attacked are obtained and carefully studied. Besides distributing guns of different calibers along the front and collecting large quantities of ammunition for use during the artillery preparation, the infantry and machine guns are carefully instructed as to their tasks. The machine guns must be used in such a manner as to best aid the infantry. The brigade machine-gun officer must have full knowledge of the plan of operations at the earliest possible moment, so that he can make detailed plans for the machine guns of the whole brigade. These plans will be made in consultation with the brigade commander, who will, after approval, issue the necessary orders for carrying out their part of the plan.

In making his detailed plan for the use of the machine guns of the brigade, the brigade machine-gun officer must make a careful study of the enemy's front line and its relation to his own trenches. He must also study the ground in rear of the enemy's front line, which he will be able to do from the aeroplane maps.

Machine guns are the weapons most likely to hold up an attack, and every effort must be made to locate enemy's machine guns, in order that some of our machine guns may be detailed in pairs, if possible, to engage them immediately the bombardment ceases.

After studying the situation in connection with the brigade commander's plan, the brigade machine gun officer then divides up his guns and gives them the individual tasks that will coordinate the whole scheme. He must make sure that the machine gun positions that he will use at the beginning of the attack are in good condition, well supplied with ammunition, and that all arrangements have been made for rapid communication.

In this manner each machine gun, or group of machine guns, will have a specific task allotted to it, and before the action commences, all concerned will thoroughly understand their duties and the particular part that they are to play in the attack.

All machine guns must be in their allotted places and ready for action by the time the artillery bombardment commences.

THE ALLOTMENT.

1. Some to go forward with the attacking Infantry.—The number to go forward with the Infantry will be determined by the nature of the enemy's trenches, the length of the line to be attacked, and the number of machine guns available. These machine guns will go forward with the fourth wave of the attacking Infantry, mingling with the Infantry so as to make an inconspicuous target. These guns will, at first, use the light muzzle tripod. The heavy tripod will be brought forward after the Infantry is secure in the trenches that it is to capture.

These machine guns hold themselves ready to go forward at the earliest moment and should not open fire until they reach the advanced position.

Their rôle will be to make good against a counterattack, the ground gained by the Infantry, and the approximate locality in which they will be mounted in the captured line should be settled before the advance begins.

2. Some to cover the Infantry advance.—The positions that these machine guns will take will depend upon the configuration

of the ground and the position of the enemy trenches in relation to our own, as well as the nature of the attack.

Their rôle is to deliver a covering and flanking fire. In playing this rôle some of the machine guns will be placed to prevent the cross fire by rifles and machine guns from the enemy trenches, situated on the flanks of the attack; some to bring oblique and enfilade fire on the part of the enemy trenches to be attacked; and some to sweep the ground over which enemy reserves must move to the counterattack; some machine guns may be pushed out to the front through saps previously prepared to keep down the enemy's fire while our Infantry is getting out of the trenches and through the wire entanglements.

All covering machine gun crews should be instructed that when our Infantry masks the fire of their guns, they should, if possible, direct their fire past the flanks of the attacking Infantry, in order to keep down flanking fire and to prevent flank attacks; also, if our troops are forced to lie down between the trenches, that these machine guns must try to keep down the fire of the enemy's rifles and machine guns.

It must be understood by all commanders, that each machine gun has been given a specific task in a concerted plan and that the machine guns must not be interfered with or their orders changed by any one except the machine-gun commander or the commander of the brigade.

3. Some in reserve under the brigade commander.—These machine guns will constitute a real reserve and will not be pushed into the fight too early. From positions in rear they can aid the attack by sweeping ground behind the enemy front line and by firing against counterattacks. Indirect fire may be used in these cases, if necessary.

Cases have been reported where machine guns have been used to aid the artillery preparation by firing upon and helping to destroy the wire entanglements. Such a use was effective, but the expenditure of ammunition was not commensurate with results produced.

AMMUNITION SUPPLY.—An officer should be placed in charge of the ammunition supply, and all arrangements should be carefully made for depots and supply before the action begins.

COMMUNICATION.—The brigade machine-gun officer, as a rule, remains near the brigade commander. He will prepare for communication with all machine guns, or groups of guns, by the usual means, as well as by having a sufficient number of orderlies on hand

for this purpose should the usual means of communication become disarranged.

SUCCEEDING PHASES.—If the attack is to consist of more than one phase, a separate plan must be made for each advance.

METHOD OF GIVING ORDERS AND ALLOTTING TASKS.—Reports indicate that before an attack the brigade machine-gun officer assembles all officers and senior noncommissioned officers of the brigade machine gun units, and with the aeroplane maps of the enemy's trenches and the defended area to be attacked before him, he explains to them the plan of attack, allots the different tasks, and designates the position to be taken by each gun before the beginning of the attack and the point of the enemy's trench to which each will advance during the forward movement, announces the location of the ammunition depot, the name of the officer charged with ammunition supply, arrangements for communication, his position, and gives any other orders pertaining to the special case that may be necessary.

LATE REPORTS.—Reports received since this paper was written state that machine guns are now being manufactured in sufficient quantities to enable the Allies to make full use of them on the western front.

One report states that a machine gun company with 8 guns, of the heavy type, has recently been added to each infantry battalion of a certain power, and that additional companies, belonging to "a machine gun corps," are being formed.

These latter companies are handled in a manner similar to the artillery of the army, that is, they are assigned to special sectors according to contemplated operations and to the necessity for machine guns. These guns are all of the heavy type and are said to be in the proportion of 13 to every 1,000 infantry rifles.

The report further states that every infantry company has 16 automatic rifles, weighing 18 pounds each. The power referred to seems to use this automatic rifle in the front line trenches as a substitute for the Lewis type gun. This automatic rifle is reported to use a magazine clip holding 20 cartridges, to fire at the rate of 150 rounds per minute, and to be quite accurate up to 600 yards, beyond which range the machine gun is used.

EFFECT OF GAS ON MACHINE GUNS.—The effect of gas upon machine guns and cartridges and the method of employing the guns during a gas attack are given in the Synopsis of Principles at the end of this pamphlet.

TRAINING OF MACHINE-GUN UNITS.

Most of the belligerents abroad now have "machine-gun training centers" to which officers and men selected for machine-gun service are sent for several weeks of intensive training before being forwarded to their organizations.

Some of these centers have facilities for training several thousand men, and they keep up a steady flow of trained men toward the front. Besides large target ranges, with which all centers are provided, there are at these centers facilities for training the personnel in grenade throwing, in signaling, and for giving necessary instruction in riding and in the care of animals.

The sending of officers and men to these centers enables them to receive training from selected instructors, insures a uniform system throughout the service, and, as machine-gun officers invalidated from the front are sent to these centers for light duty, the instruction is kept up to date.

SELECTION OF PERSONNEL.—In order to have a dependable machine-gun force which can obtain the best results from the guns, a highly trained personnel is necessary. Officers and men must know their gun thoroughly. They must understand both the theoretical and practical sides of machine-gun employment, as well as the theory of machine-gun fire and of trajectories of bullets at the different ranges. The personnel should be carefully selected. The officers must be intelligent, resourceful, bold, and must have good judgment. The work is hard, so the men must have superior physique. They should be able to run or crawl from position to position carrying gun, tripod, or ammunition. Those unable to do this or without staying qualities should be transferred. They must have good eyesight. It has been the experience abroad that machine-gun units should be composed of men with a mechanical turn of mind. In addition to the above qualifications the men should, of course, be intelligent and have some education, otherwise they will not understand the range and elevation tables and the theoretical side of the machine-gun fire and of trajectories of bullets.

Men selected for machine-gun service are chosen, as far as possible, from men who have had from six months' to one year's service in one of the other arms. Others selected are very promising men from training centers who have completed their preliminary training and are ready to take up their machine-gun work at once.

Officers and men found unfit for machine-gun service are relieved or transferred at once. Abroad, every member of the detachment is trained in such a manner that he can serve on any duty or position

at the gun. This training is necessary, as one shell may disable all the numbers operating the gun and the remainder of the detachment then engaged in ammunition supply or in reserve in the dugout must take over its service.

After all are trained, the most efficient are appointed gunners and so serve until disabled. All officers and noncommissioned officers must be expert in the operation of the machine gun as well as in its theoretical and mechanical employment.

PHYSICAL TRAINING.—All members of the detachment should have daily physical exercises, running, etc.

Nothing is better than running and crawling considerable distances with gun, tripod, and ammunition over all kinds of ground and mounting it in all kinds of positions.

KNOWLEDGE OF GUN.—While the officers and noncommissioned officers of machine-gun units must be experts in everything connected with the nomenclature of the machine gun, this knowledge is not necessary to the men of the gun detachment. It is not necessary that they should know the names of all of the parts of the gun, but it is necessary that each member of the gun detachment should have just as intimate knowledge of the machine gun and its parts as an infantry soldier has of his rifle. They should be required to take the gun apart and to assemble it again and again until this becomes second nature, and they should be quizzed and lectured about springs that may become weak and causes of stoppages and jams until the ability to locate these also become second nature. Not until such intimate knowledge is possessed by each member of the detachment can a gun detachment be considered ready for the advanced work of machine-gun employment.

FIRE CONTROL.—Perfect fire control will require careful training of all grades in:

1. Estimating distances.
2. Pointing out and picking up targets.
3. Fire orders.
4. Transmission or passing of orders.
5. Visual training.

Visual training is most necessary. It develops the soldier's powers of observation and eye for the ground, quickens his intelligence, and makes the designation and recognition of targets very easy.

Training in transmission of orders impresses upon the soldier that it is his duty to make certain that all orders passed down are received and understood by those for whom they are intended.

It is believed that the finger breadth and clock systems of target designation in vogue in our service can not be improved upon for

training in target designation when the men are sufficiently advanced to receive this instruction.

TRAINING.—Assuming that the personnel to be trained is so selected that it is ready to begin machine-gun work at once, the training of machine-gun units may be divided into the following parts:

1. Mechanical.
2. Formal drill (as prescribed by the Machine-Gun Drill Regulations) and training for fire control.
3. Advanced drill.
4. Range work. But not a shot should be fired on the range until the gunner knows everything about the gun and its use.
5. Construction and occupation of emplacements, dug-outs, communication trenches, etc.
6. Tactical training.
7. Training with other troops.

While this training is practically that given for open warfare, the present war has proven that this training is sound and adapts itself easily to trench warfare whose general principles are exactly the same.

It must be remembered that in no two military operations will the situation be exactly the same; therefore, machine-gun units must not be trained for any particular conditions of warfare. General principles and broad rules alone should guide their training.

The fire value of a machine-gun well served is considered to equal that of at least 50 riflemen in open warfare, and it is claimed by some authorities that this value is even much greater in trench warfare.

To obtain such a volume of fire delivered in the most effective manner would seem to justify an enormous amount of time, trouble, and expenditure of ammunition in machine-gun training.

MECHANICAL TRAINING.—The importance of this training must not be underestimated. Its thoroughness will depend upon the mechanical knowledge of the piece possessed by the officers and noncommissioned officers. While some of this training must necessarily be imparted by lecture and informal talks, in the main it is practical and must be acquired by the individual gunner himself. The machine gun and all accessories are given to each man in turn and he is required to take them apart and to reassemble them until he is thoroughly acquainted with the place and the use of each part. The names of parts are mentioned from time to time until the gunner learns the nomenclature of the piece.

In the same way the individual members of the detachment are taught to mount and dismount the gun, to adjust the tripod, and to

dismantle it; to clean, oil, and care for the gun and all of the parts; to adjust, read, and set the sights; to load the ammunition strips and belts; load, fire, and unload the gun, with dummy cartridges; to feed the gun, to locate and remedy stoppages and jams, and to pack and unpack gun, tripod, ammunition, and all accessories upon the animals.

Mechanical training must be reviewed and repeated from time to time so that the gunners will not become "rusty" in their knowledge.

FORMAL DRILL AND TRAINING FOR FIRE CONTROL.—Formal drill, including the allocation of duties of all members of the unit, is prescribed by the Machine-Gun Drill Regulations.

TRAINING FOR FIRE CONTROL.—This training should begin early and should be given daily until all members of the unit are proficient, and thereafter the subject should be reviewed frequently in order that all members may be ready for actual service at any time.

RANGING.—The instructor, by lecture and diagrams on black-board, explains to the detachment the theory of the trajectories of bullets, explaining what is meant by the cone of dispersion, the danger zone, the beaten zone, the safety zone, the danger space, the 100 per cent zone, the effective zone, the height of the trajectory, the line of sight, angle of elevation, etc.

He also explains why it is necessary to find the correct distance or range from the gun to the target, defines ranging, i. e., "Any means adopted for ascertaining the sighting elevation required to hit a desired object."

He explains the principal methods of ranging:

- Explains other methods of ranging:

 - 1. By estimating distances. In depth...
By unit of measure.
By mil system.
 - 2. By instruments. (Special course of instruction must be given later.) Lateral. By appearance of object.
Method of averages.
 - 3. By observation of bullets.

Explains the preparation and use of range cards:

- For attack.
For defense.

Explains value and method of observation of fire:

- | | |
|--------------------------------|--|
| Methods of communication . . . | By signals.
Semaphore
Telephone.
Messenger. |
|--------------------------------|--|

By quiz it is ascertained that the men understand what has been told them. The members of the unit are then given careful practical courses of instruction in all branches of the subject in the open country. Ranging should form a part of each drill thereafter.

VISUAL TRAINING.—As stated previously, the object of this training is to develop the soldier's power of observation and eye for the ground, to quicken his intelligence and make the pointing out (Designation) and picking up (Recognition) of targets easy. This training broadens the soldier's military vocabulary and enables him to describe intelligently what he sees, as well as to recognize quickly what is described to him.

If landscape targets are available, the instruction may begin at the barracks, preceded by a lecture or an informal talk by the instructor.

He explains: That the accuracy of modern weapons makes invisibility a necessity.

That invisibility is obtained by—

1. Smokeless powder.
 2. Neutral colored uniforms and equipments.
 3. Suitable formations.
 4. Movement carried out under cover of darkness.
 5. Careful study and use of the shape of the ground.

That a trained eyesight is necessary, due to invisibility of the enemy.

That the men will have difficulty at first in observing and telling what they see, due to differences of light, to the different appearance of objects in town and in the country, to an undeveloped brain power, and to a lack of words (military vocabulary).

He impresses upon them that the standard each must aim at is—

1. Ability to distinguish the enemy from his surroundings.
 2. Ability to report what he has seen.
 3. Ability to recognize objects described to him.
 4. Ability to train the gun on the desired object.
 5. Ability to study the ground and use it intelligently.

After these preliminary talks the instruction is given in the country, where a varied terrain is selected.

1. Single silhouette targets and groups of these targets are placed in different positions, with various backgrounds, and at varying distances up to 800 or 1,000 yards. The men are then required to locate these targets, describe their location, count the number of figures in a group, discuss characteristics of the targets, etc.

2. Individual men and groups of men then take the place of the targets. An officer is sent out with these men to select their positions, direct their movements and to cause blank cartridges to be fired so as to train the unit in locating sounds.

The units under instruction then locate, recognize, and describe these targets in the same way as was done with the silhouettes. They also state the direction of the shots fired, their number, and whether they were fired by riflemen or by machine guns.

3. Definite lines in the landscape, areas of ground, and roads are then taken up, examined and described, in detail.

Areas of ground are then divided into sections, both laterally and in depth (i. e., foreground, mid area, and background), and these sections are examined and described in detail, as above.

The above instruction gradually passes into the Designation and Recognition of targets.

The instructor defines Designation, i. e.: "The shortest and most easily understood description of an aiming point by a commander."

Also Recognition, i. e.: "The gunner's understanding of the exact point at which his commander wishes him to aim."

He explains that accurate "Recognition" is necessary to insure that the cone of fire will strike the target desired.

In this instruction the enemy's front is always pointed out, and the target and other objects pointed out must be described as seen by the naked eye. This is the normal method. Aids will not be used except when necessary.

Later, when the instruction has advanced sufficiently, the men are taught to use the glasses and the telescope; they are also taught the "Designation" and "Recognition" of targets by the aid of—

1. Reference points.
2. Finger breadths.
3. Clock-face method.

All of this instruction, besides increasing the military vocabulary of the men and teaching them self-reliance, gives them a trained eyesight, and soon they will be able to recognize quickly the points upon which to aim the gun.

As soon as sufficient progress has been made, the machine gun is taken into the open country, where the instructor indicates aiming points, and the gun is pointed at the target as the gunner understands it. The "Recognition" by the gunner is always checked.

FIRE ORDERS.—Whenever fire is simulated, correct fire orders should always be given for the class of fire desired, so as to accustom the men as soon as possible to receiving and executing these orders.

Before giving "Fire orders," the instructor must give a definition of the term, and he must also define "Ranging fire," "Rapid fire," "Searching fire," "Traversing fire," "Fire with combined sights," "Overhead fire," "Indirect fire," etc.

He will explain: That the commander will take a position from which he can best observe the fire of his guns and the movements of his own troops and those of the enemy.

That "Fire orders" may be verbal, signaled, or written.

That they will be by word of mouth when practicable.

That they may be transmitted by orderlies, who must be sure to repeat the order correctly and to see that it is understood.

That "Fire orders" may be given to a single gun, to single platoons, to several platoons, or to the whole unit.

That necessity may require them to be given direct to the squad leader instead of through the platoon commander.

That there may be occasions when orders for the entire unit will have to be sent to the right or left gun and then passed from gun to gun along the line, and that the commander would then, if possible, take a position on or near a flank.

That where "Fire orders" are given by word of mouth or repeated in this manner they must be given calmly, with telegraphic brevity, sufficiently loud for everyone concerned to hear, and with pauses so that each part may be understood, acted upon, and repeated if necessary.

That it has been found best to designate the range first,^a to indicate the target next, and then the number of rounds and class of fire.

That fire is usually begun and stopped by signals.

That alterations of the range are given by the words "Up" or "Down," adding the required amount, as is done by artillery commanders in giving their fire orders.

^a So that after sights are once set it will not be necessary for the gunner to take his eyes away from the direction of the target.

ADVANCED DRILL.—The scope of the instruction given in this class of training will depend upon the ingenuity and the interest of the officers conducting the training.

This instruction should be given where there is a varied terrain, as it has in view the adaption of the terrain to *different assumed situations* and includes the carrying of gun, tripod, and ammunition by crawling and creeping over all kinds of ground to selected gun positions without being seen, the occupation of these positions, the preparing of range cards to all likely positions of the enemy and to prominent objects, simulating suitable classes of fire from these positions, the selection of secondary positions and preparing range cards for them, the occupation of these secondary positions without observation by the enemy and simulating fire from them, then withdrawing to a position in rear or on a flank still without being seen, practicing fire orders in all of these positions, and communication to the rear and to other gun detachments, as well as providing for an adequate ammunition supply in all of these situations.

This instruction naturally merges into tactical training, as the line of demarkation is rather dim when instruction is begun on varied ground.

RANGE WORK.—This is perhaps the most important part of machine-gun training. After the men have passed tests in their elementary instruction, their range training is begun. A varied terrain must be selected for the range training in order that the proper kind of instruction may be given in all classes of fire.

The training consists of two courses:

- I. Instructional.
- II. Advanced (including tests for classification and combat exercises).

INSTRUCTIONAL.—In this course officers and men are taught proper firing positions, correct laying, steady holding, and given practice at short known distances in fixed, distributed or traversing, and searching fire.

By requiring each individual to prepare the machine gun for action, to mount it and make the preliminary tests necessary to assure him that the gun is "tuned up," to set the sights, load, and take correct firing position, to hold the gun steady while firing, to correct stoppages and jams, and then to unload, dismount, and care for the gun, all in turn and without assistance, will develop self-confidence, a most necessary quality for a gunner.

No records are kept of this firing other than of ammunition expended and of progress made. No time limit should be imposed.

Each gunner under instruction should have ample time to learn his lesson, and when necessary the particular firing exercise should be repeated.

The instructor watches the firer—not the target. If mistakes are made he causes the fire to cease and makes his criticism.

Range discipline is carefully maintained and all safety precautions are taken.

ADVANCED RANGE WORK.—The aim of this instruction is to train the units in all classes of fire and to such a degree of perfection that machine-gun commanders may be sure that the fire from their guns will be applied to the best tactical advantage when the necessities of the combat remove them from the fire direction of superior officers.

The practice includes ranging fire, observation of fire and making corrections due to the observation, firing from successive positions, firing with combined sights, night firing, searching fire, distributed or traversing fire, fire with an auxiliary line of sight, overhead fire, fire sweeping reverse slopes, and indirect fire.

The ranges being unknown, the units apply their previous instruction in finding the correct range, or fire a few ranging shots, observing the fire and making corrections. They are taught to study climatic conditions and to apply corrections of elevation, as well as the use of wind tables. Here they have practice in both classes of traversing fire on screens or targets, and they are taught how to deliver searching fire without leaving gaps between the effective zones. The dangers of overhead fire are pointed out, and the units are taught how and when this class of fire may be used with safety. They are given practice in sweeping reverse slopes and in the use of indirect fire, as well as practice in making necessary preparations for and executing night firing.

After this course is completed a classification test is given, in which a time limit is introduced and gunners are qualified and rated.

After the tactical training is well advanced, combat exercises are then taken up in connection therewith, the targets and groups of targets being arranged to appear at unknown ranges and to fit in with the particular tactical situation assumed.

NOTES ON DIFFERENT CLASSES OF FIRE.—As a general rule, machine-gun fire will not produce results commensurate with the amount of ammunition expended unless the target is included within the area beaten by 75 per cent of the bullets directed upon it.

If an error greater than half the length of this zone is made in estimating the range, the fire will be ineffective. The error in a range

obtained by a range finder will probably be 3 to 5 per cent and that by other methods may be 10 or 15 per cent. It may also be remarked that the probability of error in the range increases with distance. The only way to be sure that you have the correct range is by observation of fire, which is not always possible. If observation is possible, the observation of a few ranging shots will give you the necessary correction, but ranging shots can not be fired when surprise is intended and is of importance.

In these cases an effective zone is made certain by the use of "Combined sights," or by "Searching fire."

These classes of fire are used against deep targets, such as bridges and roads.

COMBINED SIGHTS.—In this class of fire two or more machine guns work together to increase the depth of the effective zone, by using different elevations and the same aiming point. The effective zone is thus lengthened though the density of fire is reduced. The difference of elevation between guns will depend upon the number of guns available, after taking into consideration the probable error in obtaining the range, and the effective zone for each gun at the particular range to be used. The differences of elevation must be such that no gaps will be left between the 75 per cent zones of the different guns.

It seems to be the practice to use combined sights differing by an elevation of 100 yards for ranges between 800 yards and 1,200 yards, both inclusive, and sights differing by 50 yards above 1,200 yards.

The machine-gun commander must use his judgment in modifying the application of the above, in accordance with the facilities that he has for accurately obtaining the range, so that the desired tactical advantage will be gained without a useless expenditure of ammunition.

Firing with combined sights should be discontinued as soon as accurate observation of the strike of the bullets can be obtained. A simple way of giving the fire orders for combined sights is to give the minimum elevation to a flank gun (usually the left) and to announce the difference of elevation desired. If, as a result of his observation, or for other reasons, the machine-gun commander wishes to alter the sighting, the quickest method will be to bring the elevation of the left-hand gun above that of the right-hand gun or to lower the elevation of the right-hand gun below that of the left-hand gun, according to whether the elevation is to be increased or decreased.

SEARCHING FIRE.—This class of fire is used when only one or two machine guns are available and combined sights will not or are not likely to overcome errors in obtaining the correct range. This class of fire requires quite a degree of skill on the part of the gunner to avoid gaps in the swept zone.

The size of the shot groups or bursts to be fired will depend on the nature of the target engaged.

A simple method of using this class of fire is given in one report as follows:

When one gun is being employed for searching, the sights are adjusted so that the first shot group will include the lowest range to be searched, which is determined by the expected error in the range.

The gun is now laid on the aiming point and the sights adjusted, without relaying the gun, so that the last shot group will include the highest range to be searched. The line of sight will now strike the ground short of the aiming point. A burst is now fired (10, 20, or 30 shots, depending upon the nature of the target), after which the elevating wheel is turned to cause the next burst or group to strike sufficiently far beyond the first to insure an overlap of the effective zones. This is continued until the line of sight is again brought on to the aiming point.

When using two guns, the left gun will act as described above, while the sights of the right gun will be adjusted in the first instance to the highest limit to be searched and will work down to the lowest limit.

Searching fire will be discontinued when observation of results is obtained.

The effect of ground rising with respect to the line of sight must be taken into consideration when either combined sights or searching fire is employed.

DISTRIBUTED OR TRAVERSING FIRE.—This class of fire is employed against a linear target.

The normal method of traversing is by means of a series of small groups; with the object of covering as wide a front as possible and producing the desired effect without too great an expenditure of ammunition. In the normal method the bursts or groups consist of only 5 or 10 shots.

This method has certain disadvantages. It is slow and requires careful training. The effect is a puncturing one at regular intervals instead of a mowing effect, which is to be desired.

The other method of traversing is called the "Swinging traverse." In this method the traversing clamp is kept fairly loose, and the

gun is swung evenly from side to side. This method is sometimes found necessary against dense targets at close range, as in case of a rush, when the normal method would be too slow. The expenditure of ammunition is so great when the "Swinging traverse" is used that it may be said that this method will be reserved for emergencies. Fire can be distributed by this method over 30 yards of front at close ranges in five seconds.

NIGHT FIRING.—If circumstances will allow it, the gun is mounted and laid by day and left till night. At night some kind of an auxiliary aiming mark is placed in front of the gun and in line with the target. This auxiliary aiming mark can be a screen secured to the open side of a box, in which is placed an ordinary siege lantern or an electric torch. The screen is marked with lines to permit of searching and traversing within definite limits. If the horizontal lines of the screen are 1 inch apart, each interval will subtend an angle of 10 minutes when the screen is 10 yards from the gun. The amount that 10 minutes represents in range can be readily ascertained from the table showing the angles of elevation for the gun. The vertical lines are $2\frac{1}{2}$ inches apart, which will give a deflection of 2 feet per 100 yards of range when the screen is 10 yards from the gun.

It is found that some searching will be necessary in night firing to overcome errors in laying the gun, holding, and other factors.

When the gun position is exposed, so that the gun can not be laid during the day or where fire may be necessary from several different positions, arrangements will have to be made to bring the gun and tripod up under cover of darkness and mount it so as to open fire when required.

While it is still light the gun position is selected. This of course must be selected with reference to the target it is intended to engage. A stake is then placed in the ground 10 yards in front of the gun position and roughly in line with the target and the gun position. The officer then crawls back to the gun position and places a stake in the ground in accurate alignment with the first stake and the target. Over this last stake the gun will be set up after dark. The stakes should be vertical and the one at the gun position should not be over 6 inches above the ground to avoid being knocked over when the tripod is placed over it. If more than one target is to be engaged, other stakes are aligned between the targets and the stake marking the position of the gun. Ranges and angles of position are then taken to the different targets.

If owing to the proximity of the enemy, it should be found impossible to place a stake in front of the selected gun position, then a stake is first driven at the selected gun position and a stake in rear is placed in accurate alignment with it and the target to be engaged.

After dark a stake 10 yards out in front is lined up with the other two by means of a trench lantern. Auxiliary aiming marks are placed at night at the exact positions of the 10-yard stakes. The tripod is brought forward and set up exactly over the stake at the gun position. The gun is then mounted, given the proper elevation,^a and then the line of sight is brought to the intersection of the central horizontal and vertical lines of the night firing screen.

Allowance for windage is now made by using the vertical lines of the screen.

One report states that the flash of the machine gun in night firing will soon disclose its position, unless a burlap curtain is used to screen the flash.

The angle of departure (taken from the range tables) is the angle between the line of departure of the bullet and the line from the gun to the target.

The angle of position is the angle that the line from gun to target makes with the horizontal line through the gun.

The quadrant elevation is the angle between the line of departure of the bullet and the horizontal line through the gun. It is the sum of angle of departure and the angle of position when the target is above the level of the gun and to the difference of these angles when the target is below the level of the gun.

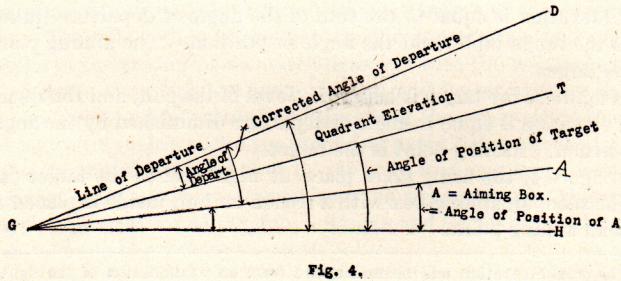
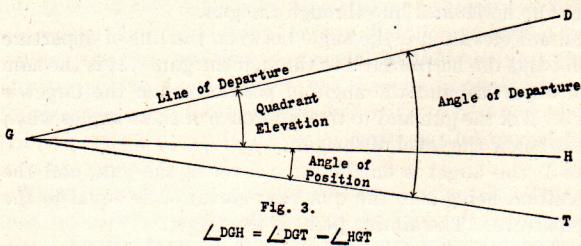
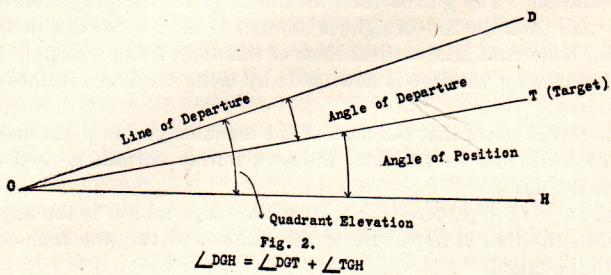
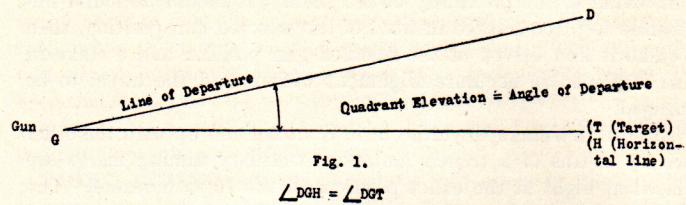
In figure 1, the target is on the same level as the gun, and the angle of position being zero the quadrant elevation is equal to the angle of departure. The aiming point is the target.

In figure 2, the target is above the level of the gun, and the quadrant elevation is equal to the sum of the angle of departure (taken from the range table) and the angle of position. The aiming point is the target.

In figure 3, the target is below the level of the gun, and the quadrant elevation is equal to angle of departure diminished by the angle of position. Aiming point is the target.

In figure 4, the firing takes place at night and as the target can not be seen, an aiming box with a trench lantern inside is placed at A as an aiming point.

^a The proper elevation will be understood from an examination of the figures shown below.



Before dark the range can be taken, the angle of departure (taken from the range table), the angle of position and the quadrant elevation for the target can be determined. After dark, as soon as the gun is set up and given the proper elevation, by means of a clinometer or other instrument measuring from the horizontal plane, the line of sight is brought to the intersection of the central horizontal and vertical lines of the aiming box by means of the tangent sight.

To hit the target while aiming at A, it is evident that a correction has been made in the tangent elevation, which in this case (as seen from the figure) is an increase equal to the difference of the angles of position of the target and that of the aiming box.

NOTE.—The formula for obtaining the angle of position at any range—

Difference in height of gun and

$$\frac{\text{target, in feet}}{\text{Range in yards}} \times 19.1 = \text{angle of position in degrees.}$$

OVERHEAD FIRE.—This class of fire refers to machine-gun fire delivered, from the rear over the heads of our own troops, either in trenches, or advancing to the attack. It may be employed under certain limited conditions. One report mentions the following factors, all of which tend to increase the difficulty and risk in employing fire of this nature and require the working out of a reasonable margin of safety:

1. The state of the machine-gun barrel.
2. The condition of the tripod and the nature of the ground on which mounted.
3. The degree of visibility of the target.
4. Errors due to obtaining the correct range and to climatic conditions.
5. Accuracy of laying and holding by the firer.

The flat trajectory of modern ammunition precludes overhead fire at short ranges, for the gun position, our troops, and those of the enemy are then practically in the same place. At long ranges the dispersion of the cone of fire and the difficulty of getting the correct range may make it dangerous.

This authority says overhead fire, therefore, may normally only be employed under the following conditions:

1. When the machine gun is fired from or at a commanding position, or across a valley.
2. When the distance to the target has been obtained accurately, that is, by an expert range finder, who can guarantee the distance as correct within 5 per cent.

3. When the gunner is an expert firer.

4. When an angle of 30 minutes is formed by the intersection of imaginary lines drawn from the target and heads of friendly troops to the gun, the distance to the target being 1,000 yards or under. If the distance to the target is over 1,000 yards and not more than 1,500 yards, the angle thus formed must not be less than 60 minutes. (These angles may be different with our ammunition and flatter trajectory.)

If the distance to the target is over 1,500 yards, direct overhead fire should not be employed, as the position of the lowest shot of the 100 per cent cone for ranges over 1,500 yards is uncertain.

It is remarked by this authority that the foregoing may be modified *provided accurate and reliable observation* is obtained. This, however, is a matter for the exercise of judgment and common sense on the part of the machine-gun commander, for too much reliance must not be placed upon the ability of an observer to pick up the cone of fire during an attack. The fire of the attacking troops, as well as of the supporting troops, together with the artillery may be such that the machine-gun cone of fire can not be picked up correctly.

There are several methods of obtaining the safety angles of 30 and 60 minutes, in use abroad:

(a) By means of prismatic field glasses, graticulated for the *particular kind of ammunition in use*. For example, the distance between the zero line and the 600 or 700 or 800 yard graticule would subtend the desired angle for ranges 1,000 yards or under, while the distance between the zero line and the 1,000 or 1,100 yard graticule would give the angle for distances between 1,000 and 1,500 yards. This method of obtaining the safety angles is unreliable, since it is quite possible for the wrong lines to be used.

(b) By means of a machine gunner's protractor. In this method the protractor is held vertically at the full length of the cord from the eye. Lines have previously been placed upon the protractor at such a distance from each other as to mark angles of 30 minutes and 60 minutes when held at a certain fixed distance from the eye.

(c) By means of the tangent sight:

Lay the gun on the target with the correct elevation, then if the distance to the target is under 900 yards, move the slide up 400 yards; if 900 yards or more, move up the slide 250 yards. In each case adopt the auxiliary aiming mark thus found. Plate 15. (These amounts will differ with our ammunition.)

The report discusses the advantages and disadvantages of this latter method as follows:

In one sense it is against the principles of machine-gun training which emphasizes the importance of the gunner looking at the target and not along his sights when firing. Again the gunner, having carefully marked the spot on which the sights are aligned, is trained to take the heads of the advancing infantry as his aiming mark when they reach and move in advance of this spot, or rather when their heads come into his line of sight, a proceeding which may not always be desirable.

The chief advantages are that each gunner can obtain the safety angle for the particular troops he is supporting; when the troops who are being supported pass the spot marked as an aiming mark, the gunner can still continue firing by elevating the gun so as to maintain his aim on their heads. As the advance continues, his aim is kept on their heads by turning the elevating wheel. By this means, covering fire is maintained until the friendly troops reach the enemy's position. The cones of fire pass over the heads of friendly troops with a margin of safety at each advance, and search ground in rear of the defended position possibly occupied by supports and reserves.

The disadvantages of this method can be minimized by the machine-gun commander using a protractor as a check on the firer, and this is particularly necessary when the nature of the ground onto which fire is being directed gives a false impression as regards the limit of safety.

INDIRECT FIRE.—This class of fire will be used on rare occasions. It is rendered possible by the "fixed mounting" of the machine gun. Lewis guns and others of a similar nature must never be used, owing to the fact of their being "air cooled" and fired from light mountings.

Indirect fire may be of value in annoying the enemy and affecting his morale, but except under unusually favorable conditions, can not be expected to inflict serious loss. It may be used to cover areas of ground, to sweep roads, etc.

It requires in most cases a great deal of preparation and accuracy in calculation. Under certain conditions it may positively be dangerous to our own troops. Indirect fire facilitates fire control, since the gunners are not exposed to aimed rifle fire. In this connection, advantage of concealment from the enemy's artillery must not be overlooked.

SPIRIT-LEVEL METHOD.—With the aid of an ordinary carpenter's spirit level, indirect fire can be quickly and accurately

applied with machine guns, to a target which is invisible to the firer. The conditions necessary for success with this method are:

(1) The target must be visible to the controlling officer from a position behind and slightly above the gun.

(2) The gun must be far enough away from the obstruction to insure the bullets clearing it. This can only be ascertained definitely after the correct elevation has been placed on the gun to hit the target.

(3) The gun and target must be approximately on the same level.

(4) The controlling officer, or the range taker, must observe the fire through field glasses or the range-finding instrument respectively, preferably from a flank.

The method of employing this fire is described as follows:

(a) The controlling officer raises his head only just sufficiently to enable him to give orders to the gunner as to aligning his gun on the target for direction only.

(b) Having finished aligning the gun, as described above, the controlling officer now gives the following orders:

1. Sights at zero.
2. Level gun with spirit level.

This is done with the Vickers or Maxim gun by laying the spirit level on the top of the breech casings and then by moving the elevating wheel until the bubble in the spirit level is central.

3. Place an aiming mark where sights are now pointing on near side of obstruction.

For example, a stone or handkerchief, or anything the gunner can see plainly.

4. 800 (or whatever the range to the target happens to be from the gun position).

5. Relay on aiming mark.

6. Ascertain if shots will clear obstruction by adjusting the sights for the distance to the obstruction. If the line of sight now clears the obstruction, the cone will also clear.

7. Fire (or signal of fire).

Since the gun is now laid with the correct angle of elevation for the range to the target on the sights, the bullets will now strike the target or in its vicinity.

Any necessary alterations in elevation or in deflection are made according to the results of the fire which will be signaled in by the range finder observing through his powerful instrument.

This method must not be employed when firing over the heads of our own troops.

SPIRIT LEVEL, CONTOURED MAP, AND ELEVATING DIAL.—From the map ascertain the distance to and difference in height between the gun position and the target. From this work out the angle of position in minutes by the formula.

$$\frac{VI \times 19.1}{HD} = D,$$

in which VI is the difference in height of gun position and target in feet, HD is the distance from gun to target in yards, and D is the angle of position in degrees.

Add or deduct the angle of position thus found to or from the angle of departure for the distance (from range tables), according to whether the target is above or below the gun position. This will give the quadrant elevation to be placed on the gun.

To place the required quadrant elevation on the gun: Level the gun by spirit level, the gunner holding the while slip dial around till zero is under the pointer, without disturbing the bubble. Clamp dial to, but without disturbing, the elevating wheel. Some of the guns are so equipped that one revolution of the elevating wheel equals 4 degrees elevation or depression on the gun. To obtain an angle of elevation of 8 degrees, the elevating wheel would have to be revolved twice. To set off a lesser amount, use is made of the subdivisions of 5 minutes into which the 4 degrees are divided. These 5-minute subdivisions are easily subdivided by the eye.

When the required elevation has been placed on the gun, put a suitable aiming mark in position between the gun and target; the night firing screen will do for this purpose. Raise the slide of the tangent sight as when firing by night without altering the elevation of the gun. The direction of the target can be obtained by means of the traversing dial, or prismatic compass. During pauses in the firing the gun *must* be relaid on the auxiliary aiming mark. The spirit level should also be placed on the gun at frequent intervals and the gun leveled. If the zero mark on the dial is then not opposite to the pointer, the dial should be unclamped and adjusted so that the zero mark is in correct position, as described above. The correct quadrant elevation should then be placed on the gun and the tangent slide altered as necessary.

CLINOMETER AND CONTOURED MAP.—From the map ascertain the necessary quadrant elevation to be placed on the gun. Now set the clinometer to the required reading, and place it on the cover with the arc to the rear and with the long edge parallel to the axis of the barrel. Turn the elevating wheel, the gunner holding correctly, till the bubble is central. Place an auxiliary aiming mark

in position. The clinometer should be placed on the gun at frequent intervals and the elevation checked.

When firing over the heads of our own troops no clinometer should be used *unless it has been tested* and, if necessary, corrected, *immediately prior to firing*.

GRATICULE METHOD.—By means of graticules cut across the focal plane of a pair of prismatic field glasses, indirect fire can be as quickly applied as ordinary direct fire.

These graticules represent the angles of elevation for the gun with *some particular kind of ammunition*. The topmost graticule represents zero, and the lines below represent every 100 yards upward from 200 yards.

Proceed as follows:

1. Obtain the range to the target.
2. Move to a position whence you can observe the target through graticulated field glasses, look at the target in such a way that the graticule representing the range to the target falls across the target, then look for a suitable aiming mark above the target (which aiming mark must be visible from the position where the gun is mounted) and see which graticule falls across this aiming mark.

The range corresponding to this graticule gives the angle of departure at which to open fire, using the suitable aiming mark to lay the gun on. By this means great accuracy is obtained while the gun and firer are invisible to the enemy.

This method becomes inaccurate when the eye of the officer using the graticulated glasses is more than 6 feet above the gun.

It is important to get an aiming mark virtually above the target, making any necessary allowance for wind. If it is found necessary to increase or decrease the elevation after fire has been opened, since the position of the slide does not indicate the range to the target, another method other than the normal must be employed. (There are roughly as many clicks on the ratchet of the tangent sight as there are hundreds of yards in the range, at all ranges below 1,500 yards.)

LONG RANGE SEARCHING FIRE.—In trench warfare, where the positions of our own and the enemy's troops are clearly marked, long range searching fire, over the heads of our own troops, may sometimes be safely employed.

To obtain the best results, observation of the strike of the bullets is essential. The element of chance, due to errors in ranging, climatic conditions, errors as to the exact position of the gun, etc., will thus be removed.

When observation of results is possible, fire may be directed on the hostile support or reserve lines, communication trenches, etc. When no observation is possible, the most that can be hoped for is to engage an area of ground with the object of sweeping reverse slopes of hills which are defiladed from fire at short ranges, interrupting traffic on roads, etc.

To insure the safety of our own troops, the following must at all times be strictly adhered to:

1. No target should be engaged at a range of less than 1,500 yards.
 2. The guns must never be more than 1,500 yards distant from bodies of our own troops, over whom they are firing.
 3. When the guns are 1,000 yards or under from our troops, the range at which they are fired must be such as to insure the center of the cone of fire passing at least 60 feet over their heads.
- When the guns are between 1,000 yards and 1,500 yards from our own troops, this height must be 125 feet.
4. The position of our own troops with reference to the gun must be accurately ascertained.
 5. When there is a *negative* angle of position between the gun and target, or a *positive* angle of position between the gun and our own troops, the heights shown in the trajectory table will be reduced. The guns must, therefore, be moved back to fire at a range which will give the required safety limits under these conditions.

6. Climatic conditions must be carefully studied.
7. As a slight sinking of the tripod during the firing may seriously affect the safety of our own troops, owing to the altered angle of elevation, every precaution must be taken to prevent this happening. The legs of the tripod should be firmly imbedded in the ground, and provision made to prevent them moving from their original position.
8. When "traversing" and "searching" is used, provision must be made in the shape of wooden battens, etc., to limit them to a safe amount.
9. A worn barrel should not be used.
10. All calculations must be carefully checked before firing.
11. Troops over whom fire is to be opened must be cautioned, and a certificate to this effect signed by the machine-gun commander.
12. Clinometers, if used, must be tested, and if necessary, corrected, before use. To direct fire on a target invisible to the guns, a map having a scale of not less than 3 inches to one mile must be used. In order to find the correct elevation, the map must be contoured.

The following information is required from the map:

The exact position of the gun, the direction and distance between the gun and the target, and the angle of position of target with respect to the gun. Small errors in the position of the gun will cause serious errors in direction.

The position of the gun on the map can be found by "resection." (Par. 34, Engineer Field Manual.)

The direction of the target can be obtained by means of a compass bearing, or by the use of the traversing dial.

To find the direction with the traversing dial proceed as follows:

Select some convenient object visible from the gun position, which can be identified on the map for use as a reference object. On the map draw lines from the gun position to the reference object and target. Measure with a protractor the angle formed by these two lines at the gun position.

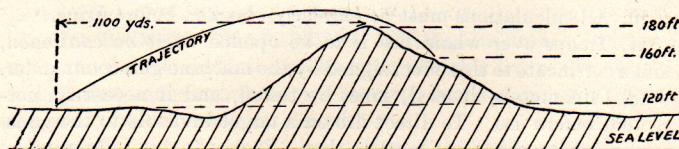
Place the gun in position on the ground and lay on the reference object. Note the reading shown by the pointer on the dial. Add or deduct this reading from the angle already obtained from the map, according to whether the reference object is to the left or right of the target.

When the reference object it is desired to use can not be identified on the map, its compass bearing must be taken from the gun position and "plotted" on the map. The required angle can then be measured and used with the traversing dial as before.

To place the required elevation on the gun use either of the methods of "Indirect fire" previously described (spirit level or clinometer).

To facilitate the making of notes on angles of elevation, bearings, safety of our own troops, etc., it is advisable to enlarge the area to be engaged.

SWEEPING REVERSE SLOPES



By selecting the most suitable range it is easy to adjust the fire of machine guns, so that reverse slopes of hills may be accurately swept by grazing fire.

The following example will show how the suitable range is selected:

From a contoured map it is noted that the enemy occupies a crest line 180 feet above sea level, the 160-foot contour being 300 yards in rear of the crest line.

Our troops are in position in a valley which is 120 feet above sea level.

Deduct 120 feet from the other two heights; the heights above our position are seen to be 60 and 40 feet, respectively, and our bullets are required to descend from 60 feet to 40 feet in 300 yards; that is, from 60 feet to 54 feet in 100 yards.

Now, inspect the trajectory table (Publication No. 1923, Description and Rules for the Management of the United States Rifle, Caliber .30, Model of 1903). Any fall of 6 feet in 100 yards will not do, as it is necessary to arrange that the bullet shall first rise to 60 feet. On inspection it is found that the 1,600-yards trajectory satisfies the condition as to rise of 60 feet and that there is approximately the required fall (from 61.7 to 56.1 feet) between 1,100 and 1,200 yards.

If, then, a line is drawn on the map 1,100 yards from the crest line and machine-gun fire is directed from a point on the line so arrived at, at the crest line, with sights at 1,100 yards or the angle of departure equivalent to this, plus the angle of position of the crest, the bullets will sweep the reverse slope.

The above method determines the best position for covering fire and aids in selecting positions for machine guns for night fire.

RANGE TABLES AND FIRING DATA.—Plates 15 and 16 show two kinds of range and firing data cards in use by one of our allies. They are prepared for each kind of ammunition used. A graticule card for both classes of ammunition is also shown.

AIDS IN THE DETERMINATION OF RESULTS OF FIRE.—Screens of suitable size, covered with paper, are used at some of the training centers for determining the results obtained from different classes of fire. For example, if it is intended to sweep the reverse slope of a ridge or hill, several of these screens are placed along the slope to be swept and between bursts results are signaled, or after the exercise, the number of hits are counted.

If there is to be practice in overhead fire, rows of these screens represent our troops at different stages of their advance and the safety angles for this class of fire are determined by sighting at the tops of the screens. There must be no hits on these screens. Other screens represent the enemy.

In the same way screens represent troops on a bridge, along a road, or the positions of supports and reserves, when practice is had, in

"searching," or firing with combined sights and also during night firing.

CONSTRUCTION OF EMPLACEMENTS, DUGOUTS, COMMUNICATION TRENCHES, ETC.—At all training centers a section of a "defended area," or a system of field works, has been laid out and constructed according to the conditions imposed by the terrain, with firing trenches, support trenches, all kinds of emplacements for machine guns, dugouts, communication trenches, reserve dugouts, ammunition chambers, entanglements, lookout posts, lines of communications, etc., just as they exist at the front. These are kept in repair and gradually extended by the labor of the men under training. At the proper time during the training period machine-gun units occupy these emplacements and are taught the routine of the trenches, during 24-hour periods. They conduct night firing from these emplacements and are taught their duties both in attack and defense under conditions as realistic as they can be made.

TACTICAL TRAINING.

(1) **Reconnaissance and study of ground.**—A reconnaissance may be made in two ways; i. e., by actually going over the ground and by studying it with glasses.

The latter will be the most usual method, so the training in the study of the ground, selection of gun positions, concealed lines of advance and retreat, etc., must be continual and thorough.

All grades, but officers and noncommissioned officers especially, should constantly practice crawling forward to a point and then selecting gun positions, lines of advance, etc., in advance of that point. They then go forward and see if their selection has been correct.

The gun detachments are then signalled to bring up the guns and directed to occupy the positions chosen. The officers observe the movements, correct errors, or suggest better methods of carrying out the movements.

(2) **Selection of gun positions.**—Daily instruction should be given in the selection of gun positions. An officer accompanied by a range-finder sergeant makes the selection. The actual position of the gun must be chosen from a lying position, the person selecting the position raising himself on his elbows until his eyes are on the level of the gunner when firing the gun.

The officer also selects the position from which he will command the guns. The range-finder sergeant, as soon as a position has been selected, makes a range card for the position, entering thereon the ranges to all prominent objects. The range-finder sergeant must not

accompany the officer so closely as to make a conspicuous target for the enemy.

The officer then selects an alternative position for each gun, which must be capable of being reached under cover from the first gun position, and the range-finder sergeant then prepares a range card for that position.

(3) **Method of bringing up the guns.**—Having selected a gun position, the officer signals to the sergeant whose squad is to occurv it to join him. The position of the gun, the targets, the range card, and the route of the gun to its position are then given to sergeant, and he conducts his squad or signals it to its position.

The squad approaches under cover to a point as near the position as possible before unpacking gun, tripod, and ammunition. From this position these are carried forward by hand.

The member carrying the tripod leads and sets it up under the direction of the sergeant. The member with the gun comes next.

Then come the ammunition, spare parts, extra barreis, etc. The packs are moved to a suitable covered position, if possible, out of the direct line of fire. It should not be necessary to give any orders to the noncommissioned officer in charge of the packs. He should be trained to keep them under cover and to maintain communication between them and the guns, sending notice of any change in his position.

(4) **Arrangements for ammunition supply.**—Great attention must be given to the maintenance of an adequate ammunition supply. Too much ammunition must not be carried to the gun position, for in case of a retirement or a sudden change of position it may be lost. Ammunition carriers bring up limited amounts, being careful not to expose themselves and thus give away the position of the gun. If the distance to the packs is great, a relay will be formed, the carrier from the pack meeting the carrier from the gun at a halfway point.

(5) **Methods of communication.**—In training, all methods of communication should be used and practiced; i. e., orderlies, semaphore, other methods of visual signaling, and telephones.

Fire orders and target designations should be given habitually on the ground by these methods, and always in the lying position, so as to practice communication, as well as the habit of concealment so necessary when in the presence of the enemy.

(6) **Reference points.**—These should be selected by the machine-gun commander and communicated as soon as possible to the squad leaders, so as to make the pointing out of targets easy.

(7) **Likely targets.**—Squad leaders and members of the squad should be practiced frequently in selecting places that are likely to be occupied by the enemy. Officers should also select these positions and point them out to the men. This practice will train the men in finding such positions and will make the pointing out and recognition of targets easier.

(8) **Changes of position.**—Practice should be given in withdrawing the gun quickly from one position and occupying an alternative position without being observed from the direction of the enemy.

(9) **Enemy's machine guns.**—One or two guns should be sent to take up positions that would likely be occupied by the enemy and then the squads should be practiced in locating them by sound and with telescopes.

(10) **Team work.**—This practice is most valuable. It consists in teaching cooperation by the different squads in concentrating the fire of all guns upon a particular target, changing the fire to another target, distributing the fire among several targets, crossing fire with that of neighboring guns, using traversing fire by some guns, and overhead fire by others and other combinations.

(11) **Choice of gun positions.**—Questions of concealment and the kind of fire desired will have great weight in the choice of a gun position; i. e., whether we desire—

Enfilade fire.

Overhead fire.

Long-range fire.

Fire against houses, etc.

Fire against enemy's machine guns.

Concealment from enemy's artillery.

Other considerations may control the choice, as—

Lines of advance and retreat.

Cover for ammunition carriers.

Facilities for control of guns.

Alternative positions.

Positions to be avoided have been mentioned before, such as obvious positions, or those easy for the enemy to pick out, and those easy to observe, as well as those near prominent objects, etc.

TRAINING OF MACHINE-GUN UNITS IN COMBINATION WITH OTHER TROOPS.—No training can be considered complete unless the machine-gun units have been trained in combination with other troops.

In this course of training, the different units should, in turn, be given *all of the different rôles* that machine-gun units will have to play on the field of battle in open warfare, and in both classes of

trench warfare. Careful and repeated instruction is given in the different duties necessary in an attack of the enemy's trenches in trench warfare; i. e., that of accompanying the infantry line, of protecting the flanks of our line, in the delivering of overhead, supporting fire, or of indirect, searching fire against the supports and reserves of the enemy, etc.

None of this training should be given until the machine-gun units are more or less expert in all of the different kinds of training outlined above, especially that classed as range work. In this training, the theoretical principles of the previous instruction are actually applied with troops and the lessons taught are brought out, as well as the importance of cooperation not only between the guns and the troops they are assisting but also the necessity for close cooperation between the guns themselves.

SYNOPSIS OF PRINCIPLES APPLICABLE TO MACHINE GUNS IN TRENCH WARFARE.

COOPERATION.

Between machine guns of any particular section of a defensive line.

Between machine guns of adjacent sections and brigades.

All ground in front swept by cross fire, forming belt of fire.

Machine-gun commanders and section commanders must be conversant with the situation.

Cooperation of machine guns from a flank against points where the enemy is very close must be arranged for.

TAKING OVER TRENCHES.

Before taking over trenches, the machine-gun commander should, if possible, reconnoiter the whole line and note—

Position of each machine gun and area covered by it.

Number, position, and nature of any extra emplacements, dugouts, splinter lookout posts, or other work to be done.

Positions and methods of communication between himself and his officers commanding sections, and between them and their guns.

He then issues any necessary machine-gun orders.

BOMBARDMENTS.

With a view to reducing losses during bombardments observe these rules:

During bombardment by the enemy, dismount machine guns and place them in strong dugouts, or if none, in bottom of trench.

Tripods are left in position, so guns can be mounted quickly.

Machine guns when dismounted will be wrapped in strong waterproof covers to prevent clogging with dirt from shell fire.

Gunners not retire to one dugout or to one part of trench, so all will be struck by one shell.

After bombardment, two men mount gun—others remain under cover.

When enemy attack is launched without covering machine gun and infantry rifle fire from the flanks, and when speed is especially important, undue attention is not paid to exposure.

Strong dugouts are provided near each machine-gun emplacement for the men.

Strong splinter-proof lookout posts are provided for use during a bombardment while the machine guns are in the dugouts.

Three or four men are sufficient in front trenches—remainder are kept in reserve trenches.

During a bombardment by our artillery, machine guns should not be fired except at a very favorable target.

AMMUNITION.

Ammunition supply must be carefully thought out.

British have 8 full belts and 4,000 rounds in unopened boxes with each gun.

Other full belts, belt-filling machines, and 4,000 in unopened boxes with spare gunners at central depot in reserve trench, or other suitable place.

Arrangements for filling belts or strips in dugouts or reserve trenches.

In wet trenches care taken to keep belt boxes out of the mud. Belts and boxes kept in ammunition recesses—clean and dry.

Ammunition not kept all together in one place.

Ammunition kept dry as possible and inspected daily. Each round turned to prevent sticking in belts.

EMPLACEMENTS.

One emplacement reserved for each machine gun as battle emplacement—never used except to meet enemy attack.

Several alternative emplacements are made—one should be open for firing over the parapet.

Every emplacement is numbered and marked and has a range card in it.

Emplacements numbered from right to left in each brigade.

After firing from one emplacement move gun quickly to another—prevents location by artillery and is good practice.

Firing from dummy emplacements will deceive enemy as to position of emplacements and to the number of guns.

Emplacements and dugouts are always kept in good repair.

In each emplacement limits to which machine gun may be traversed with safety to friendly troops are marked with posts or sandbags.

When the machine-gun position is liable to be rushed due to weak wire entanglements, or if due to the closeness of the enemy trenches it is subject to attack by bombers, the guns are dismounted and kept in the dugouts during the daytime.

Smoke helmets are worn when firing is kept up in bombproofs.

OVERHEAD FIRE.

Our troops should be notified before firing over them.

LAYING OUT TRENCHES.

When trenches are dug deliberately, machine-gun positions are chosen first—this enables trenches to be held with minimum number of riflemen.

RELIEFS.

Detachments relieved systematically to give officers and men sufficient rest.

Three or four men in front trenches at one time and remainder in reserve at central dugout, or ammunition depot, will enable front-line men to be relieved every 24 hours.

Units should be relieved every few days.

Other troops assist machine-gun organizations in carrying ammunition, revetting material, etc., when necessary.

CONTROL OF GUNS.

The machine-gun officer.

Establishes himself at place where messages can always reach him.

Keeps in touch with his guns and with the officers of the line of trenches he is assisting to defend.

Arranges for fire control and direction—usually in the trenches a man is placed in charge of each gun with definite instructions what to do in various eventualities.

ENEMY MACHINE GUNS.

Telescopes are of great value in spotting enemy machine guns, observation of fire, etc. Training of both officers and noncommissioned officers required to get best results from telescopes.

If enemy machine guns located and doing no material damage, leave them alone. If fired on they will change position. If we know their location, when our attack is launched, our machine guns can keep down their fire.

CLEANING.

Machine guns and all stores cleaned at least once daily.

BRIGHT PARTS OF MACHINE GUNS.

Painted khaki color to prevent reflection.

PERISCOPES.

Every one trained in their use. Never used near gun position but to the side.

POSITIONS—KNOWN TO ALL.

Position of machine-gun commander of any section must be known to everybody. Every gunner must know the position of every gun whether it be in the front line, in the support trenches, in reserve, or in position in rear; also the best way to them.

TRAVERSING.

The "Tap" traverse is the normal method. For sweeping parapets and repelling rushes the "Swing" traverse is used.

FIRING WITHOUT TRIPODS.

Gunners should have practice in this. When emplacements are destroyed or tripods disabled, machine guns must be fired over the parapets, with only parapet rest.

SHOVELS.

In the attack a small shovel is strapped to the back of one gunner.

OPENING FIRE.

It is a point of honor for a machine gunner to always have his machine gun "tuned up" and ready for any emergency.

VERY PISTOLS.

Every machine gun has a Very pistol to show up enemy night attacks and to enable fire to be directed upon them.

BOMBERS.

Two or three bombers protect the machine gun during an attack; also when the opposing trenches are close together. This enables machine guns to be used to best advantage. All gunners receive instruction in bombing.

ORDER BOARD.

One in each emplacement.

(Sample.) Order for sentinel and gun commander at No. 6 gun position.

Fire only to be opened by order of gun commander unless emergency arises, in which case sentinel uses his own initiative.

When relieving another gun team or sentinel ascertain:

Whether gun has been fired during the relief.

If fired, what the target was.

If fired, from which emplacement.

The sentinel will inspect the gun before taking post.

The sentinel will have accurate information of points on range card.

In case of alarm or gas attack sentinel will wake gun team.

The gun will not be mounted, except during darkness, unless the situation makes it necessary.

The gun will be cleaned daily, and weight of fusee spring noted both morning and night.

Ammunition, spare parts, and hyposulphite solution will be inspected daily.

The lock spring (return or hammer) will never be left compressed.

It is sufficient to half load and press the double button with the Vickers, or to place a magazine in position on the magazine post of the Lewis when mounting the gun at night.

In order to meet an attack complete the loading.

All dugouts, emplacements, ammunition chambers, etc., belonging to the gun position will be kept clean and in repair.

Here follows any special orders of the position.

MACHINE GUNS IN ENEMY GAS ATTACK.

Gas affects working parts of a machine gun; also the cartridges in the belt. If long exposed, impossible to fire the gun.

Gas is heavier than air—sinks to bottom of trench or dugout. Guns in dugouts or low emplacements must be removed at once and placed to fire over the parapet.

A sprayer is kept with each machine gun.

There are two courses open to the machine-gun officer:

1. To order fire to be opened with a view to—

Preventing the enemy leaving his trenches and keeping down their fire so as to enable his own troops to keep their heads high.

Encouraging his own troops.

Keeping his machine guns working, as, while in movement, the various parts are less affected by the gas and the firing of the machine gun has the effect of dispersing the surrounding gas to a certain extent.

2. To reserve his fire, with a view to taking advantage of a careless advance on the part of the enemy following up their gas. In this event he should use his sprayer constantly.

The course of action adopted will depend on the effect produced by the gas on the troops in his trench.

COMMUNICATION.

Is difficult in defense, owing to the cutting of telephone wires.

Is more difficult in attack, as enemy sometimes places a barrage of fire behind our troops after they have gone forward.

For these reasons every form of communication must be used to maintain communication between machine guns in rear and on the flanks and the troops that they are supporting.

Telephones.—Connect brigade, battalion, company headquarters, reserve dugouts, etc., with the guns, normally. The guns are also connected laterally.

Orderlies.—Machine-gun commanders and section commanders also have a sufficient number of well-trained orderlies attached beforehand.

Visual signaling.—All machine gunners are trained in semaphore signaling.

MACHINE GUNS IN TRENCH WARFARE.

The best method of insuring success is:

A carefully arranged plan of action.

To have plan understood by all concerned.

Definite orders to officers and machine-gun commanders.

Then if communication breaks down the individual on the spot can do his best to insure the success of the general plan.

The foregoing will guide machine-gun officers in choosing their own positions, which must vary according to the ground and to the tactical requirements of the situation.

DEFENSE.

For the defense of an entrenched line, machine guns of each section must be arranged by one officer.

He allots areas to each gun. These must slightly overlap.

Whole area allotted must be capable of being seen by gunner—theoretical marking of lines of fire on map not sufficient.

Trench map prepared showing position of each gun and area swept by it.

Machine-gun commanders of adjacent brigades must confer as to their flank guns.

Machine guns must cover areas that artillery can not reach or can reach with difficulty.

Aim is to create belts of machine-gun fire across the front.

Machine guns are so placed as to bring oblique or enfilade fire against:

The enemy trenches.

The ground over which he must pass should he attack.

Our own front line trenches should enemy penetrate into them.

To achieve these objects, machine guns may be placed:

In a salient.

In a reentrant.

At a bend in the trench.

In front of the trench.

In or near support or communication trenches.

In a straight portion of trench, firing through oblique loopholes.

Emplacements some distance in front of the trench, concealed, and approached by a covered sap are useful both for attack and defense.

Machine guns are, if possible, covered from fire from the front while being able to sweep the front of the entrenched line with cross-fire.

While firing to the flank, its front is swept by the fire of the neighboring machine gun.

Arrangements must be made so that machine guns may fire to the front should an emergency arise. To do this:

Arrange so that some sandbags can be removed thus making a loophole to the front.

Remember that—

If sandbags are left in position for considerable time without being moved, they may become embedded and be found immovable.

Loopholes filled with single sacks will not be bullet proof.

Train gunners to quickly remove the machine gun from the tripod and fire over the parapet, or to take gun and tripod and fire from some previously selected spot. These methods require practice.

Machine guns should always be concealed from the front.

DISTRIBUTION.

In making the distribution of the machine guns, the following positions should be considered:

In the front line trenches.—In a stubborn defense they may just make the difference between success and failure.

In or near support trenches.—To prevent further advance of the enemy should they capture the front line, to enfilade the front line should it be captured, and to sweep communication trenches.

In positions in rear.—Should the ground be favorable they can be arranged to:

Fire over trenches and sweep ground in front.

Fire through gaps in the line.

Command positions where the enemy can concentrate before attack.

Command covered approaches to the defensive line.

Command likely enemy machine-gun positions.

Give overhead covering fire when our troops attack.

Use indirect fire against ground in rear of the enemy's lines.

In strong places just in rear.—These positions should be strong and inconspicuous. They are arranged so that the ground in front is swept by cross-fire.

Some in reserve.—These are used for instructional purposes when not otherwise required.

The number of guns placed in each of these divisions will depend upon the number of guns available, but emplacements should be prepared and arrangements made to place machine guns in any of these positions if they should be required.

ATTACK.

The Brigade Machine-gun Officer must be fully informed of the plan of operations as early as possible.

He, in conjunction with the officers in command of sections, works out the detailed plan for the employment of the machine guns.

The brigade machine-gun officer will—

Make a study of the enemy's front line and its relation to his own trenches.

From a study of maps make himself acquainted with the ground in rear of the enemy front line, and also with his trench system. Aeroplane maps are required for this.

Issue definite orders to officers commanding the different sections, as to the employment of the guns, after approval of the higher commander.

Make certain that machine-gun positions which he will require are in good condition.

In this manner, each machine gun or group of guns will have a specific task. Before the action begins, all will know their duties.

All machine guns must be in their allotted places before the preliminary bombardment commences.

Machine guns are the weapons most likely to hold up the attack. Efforts must be made to locate enemy machine guns. Certain guns are detailed to engage these guns as soon as the bombardment ceases.

Machine guns have definite tasks and must not be interfered with by other officers.

Machine guns will be allotted:

Some to go forward with the attacking infantry.—The number will depend upon the front to be attacked and the nature of enemy's trenches.

Their rôle will be to make good the ground gained by the infantry.

They go forward when it is sure that the infantry is established in the captured trench.

Teams conceal their identity as machine-gun teams, by mingling with a wave of the infantry, and carrying their guns inconspicuously.

The approximate locality where each machine gun will be mounted in the captured line should be settled in advance.

Lewis guns, or guns with light mountings, should be used for this work. The heavy tripod is brought forward after the position is consolidated.

Some to cover the infantry advance.—The positions of these guns will depend upon:

The lie of the ground.

The nature of the attack.

The position of our own and the enemy's trenches.

These machine guns are allotted as follows:

Some to prevent the cross-fire by rifles and machine guns from the enemy's trenches situated on the flanks of the attack.

Some to bring oblique or enfilade fire on to the portion of the enemy trenches being attacked.

Some to sweep the ground over which the enemy's reserves may advance to the counter attack.

Some may be pushed out in front of the line, to keep down enemy fire while the infantry are getting out of the trenches and through the wire. These latter may be in saps, crops, or folds of the ground.

When the attacking infantry masks the fire of the machine guns, they should, if possible, direct their fire past the flanks of the attacking troops, so as to keep down flanking fire and prevent flank attacks.

If our troops are required to lie down between the trenches, the machine guns try to keep down the fire of the enemy's rifles and machine guns.

When their covering rôle is completed, the machine guns automatically return to the control of the brigade machine-gun officer, who will give further orders.

Some in reserve under the brigade commander.—These are retained as a real reserve, not pushed too early into the fight.

From positions in rear they may be used to sweep ground behind the enemy's front line, fire against counter attacks, etc.

SEPARATE PLANS.

If the attack is to consist of two or more phases (two or more distinct advances), separate plans must be made for each.

AMMUNITION SUPPLY.

Arrangements for ammunition supply, belt or strip filling, ammunition depots, etc., are made before the action commences. An officer is placed in charge of these arrangements.

POST OF BRIGADE MACHINE-GUN OFFICER.

With or near the commander of the troops. He provides himself with a sufficient number of trained orderlies.

Section of a Defended Area

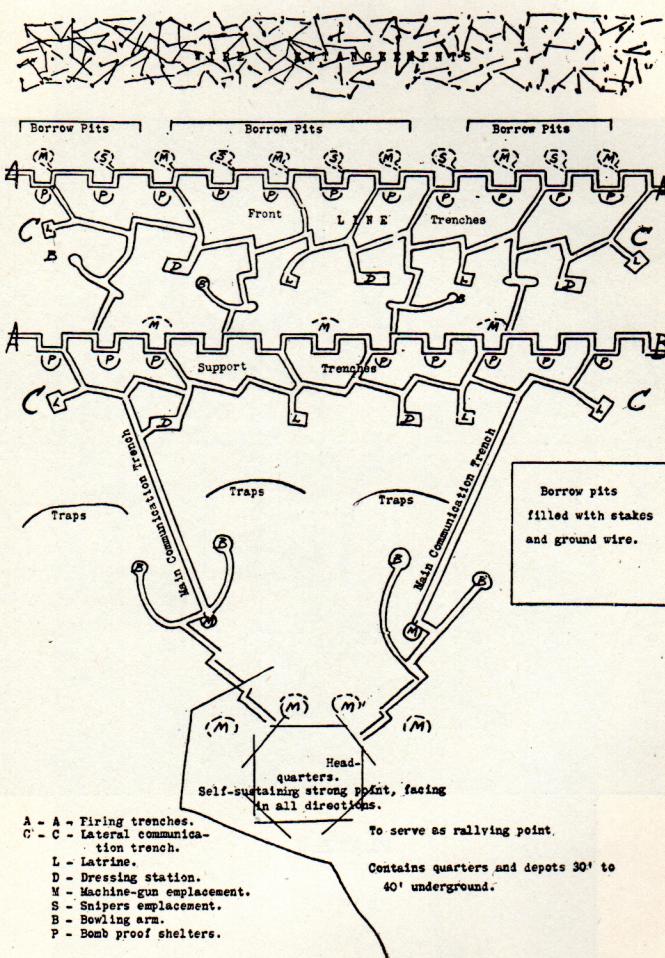


PLATE 1.

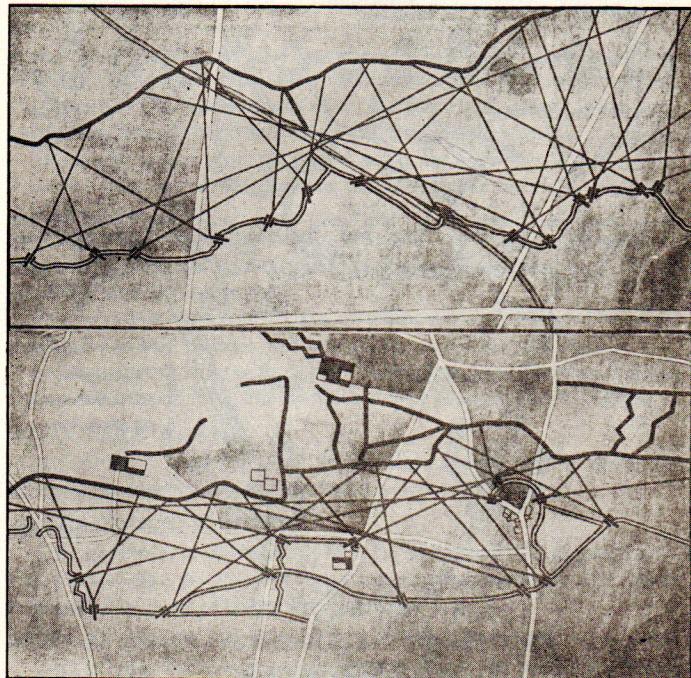


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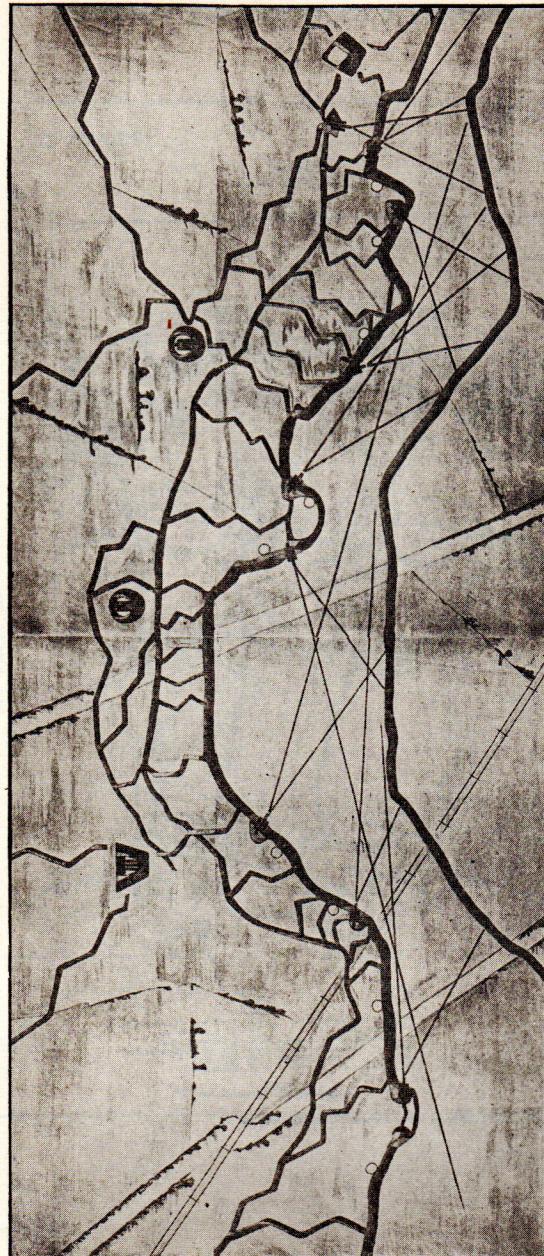
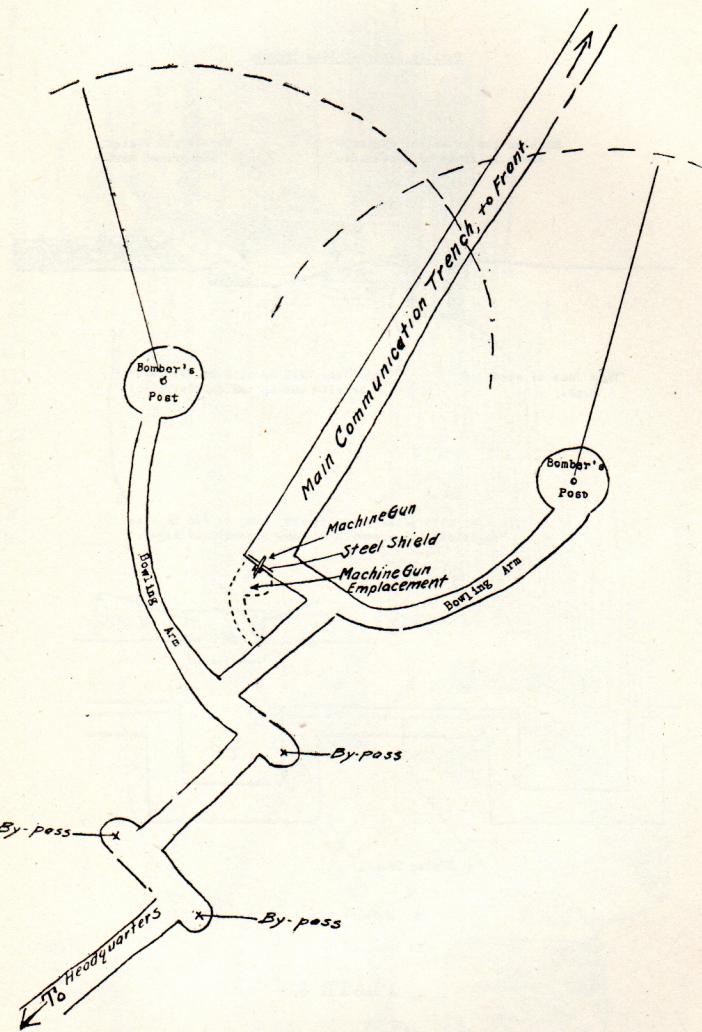
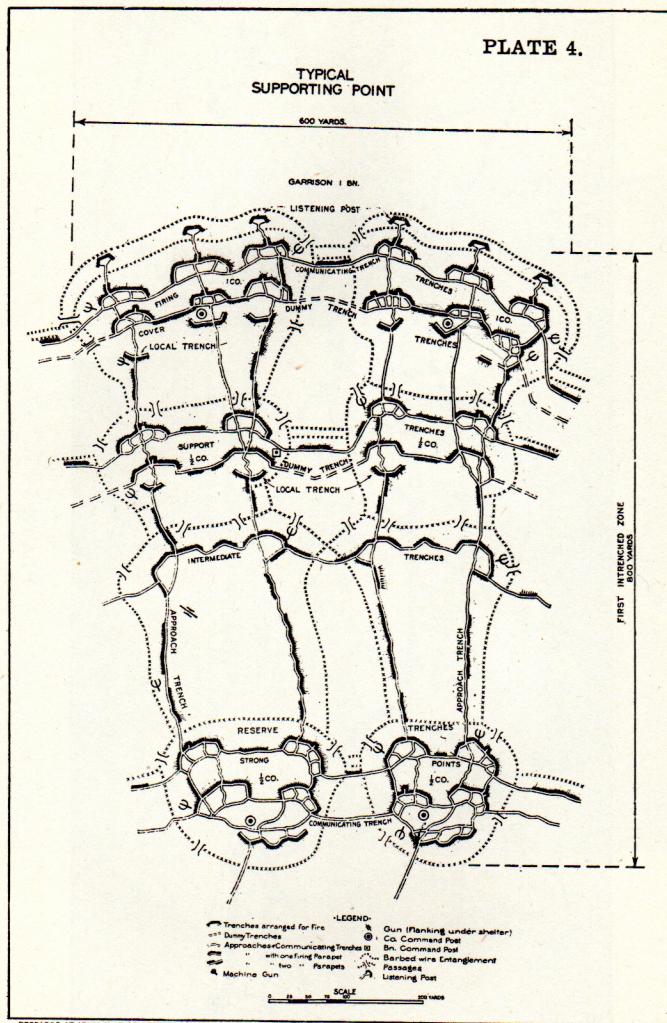


PLATE 3.



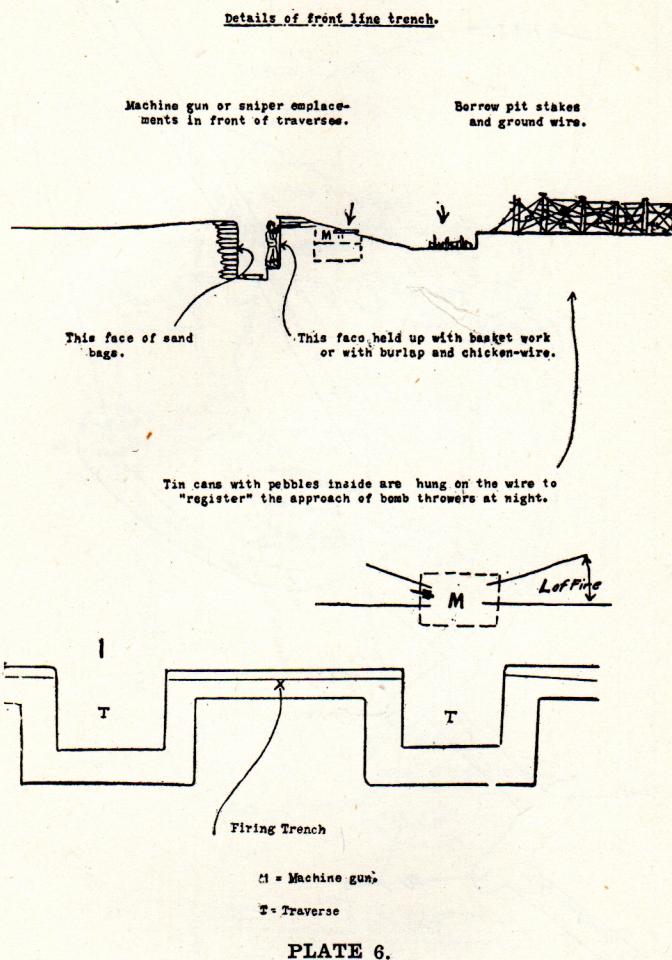
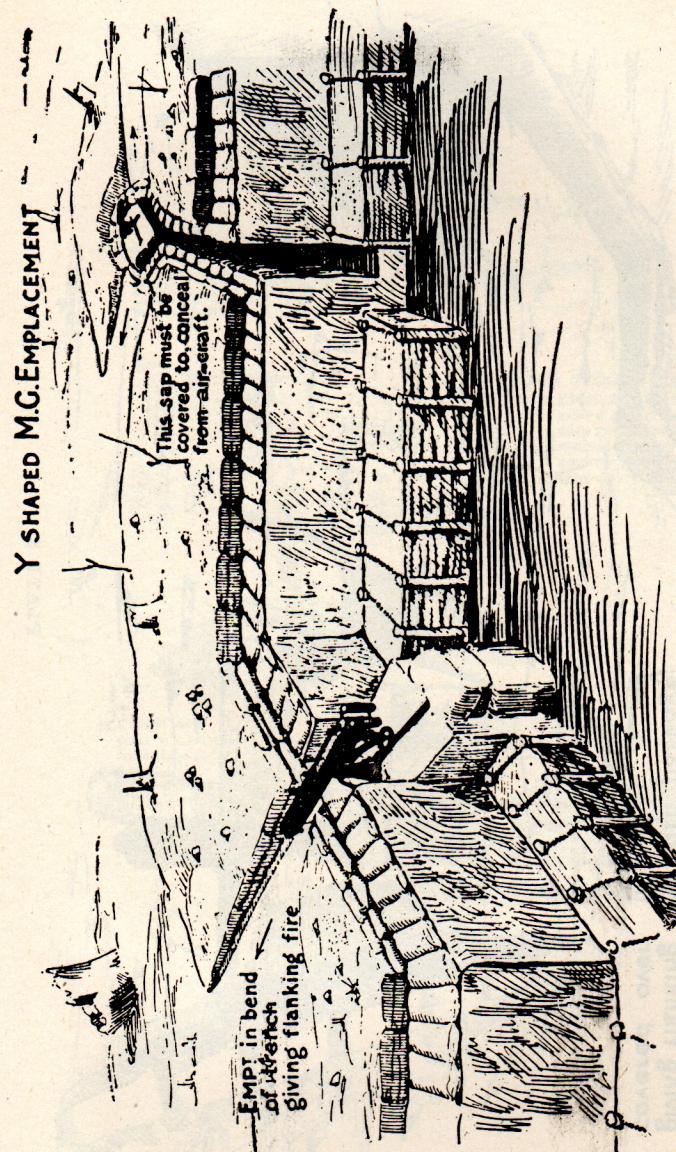


PLATE 6.



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PLATE 7.

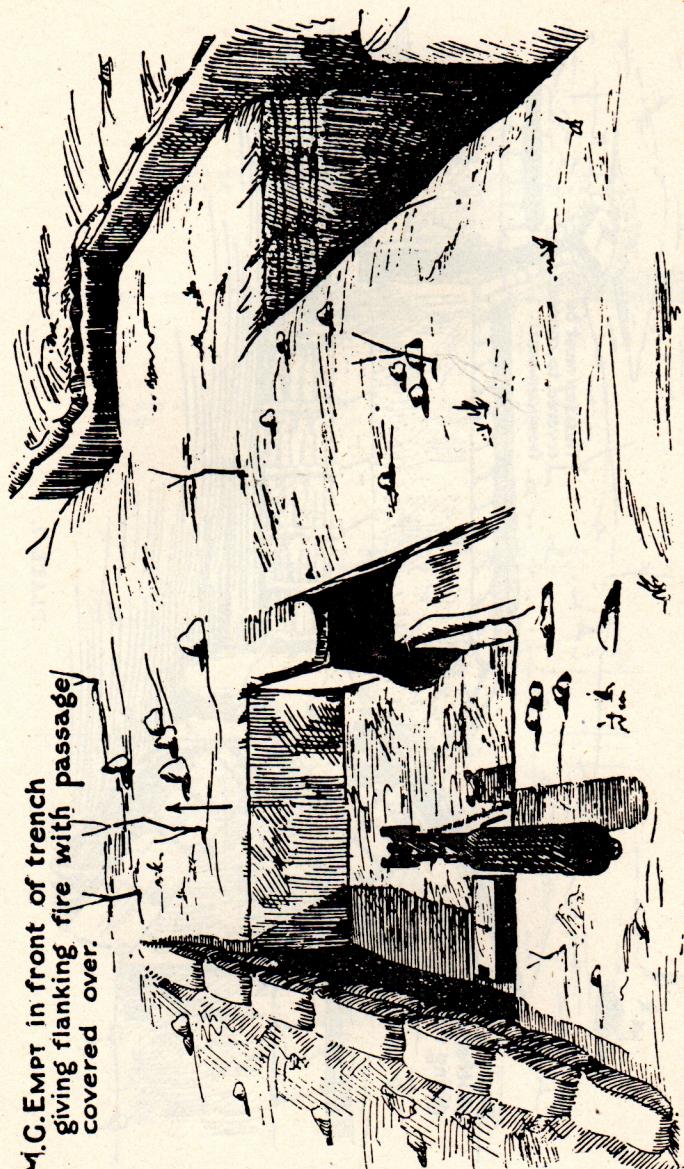


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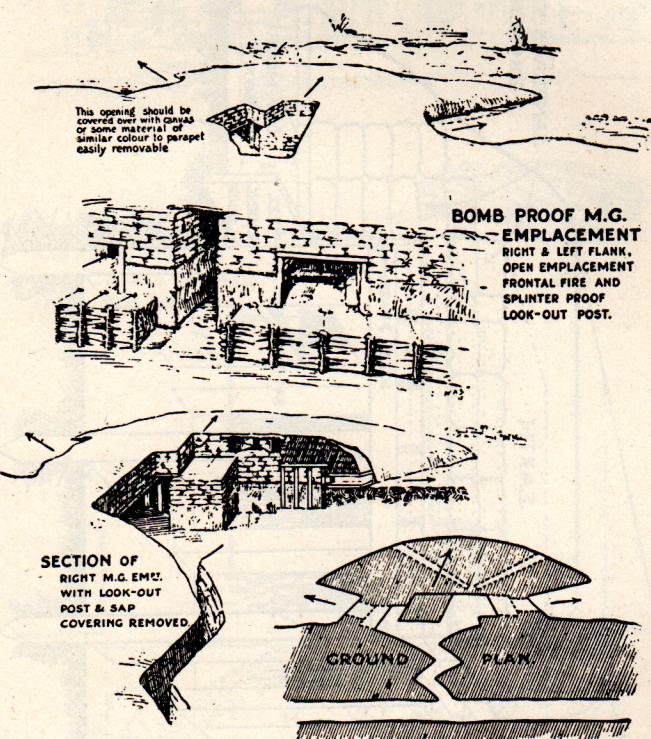


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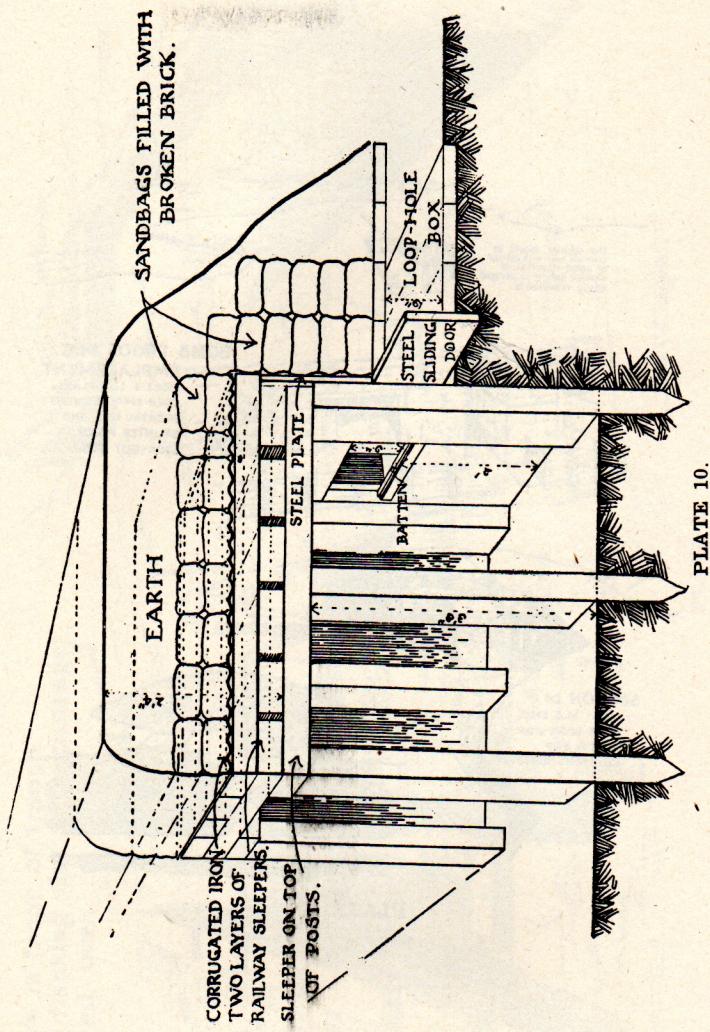


PLATE 10.

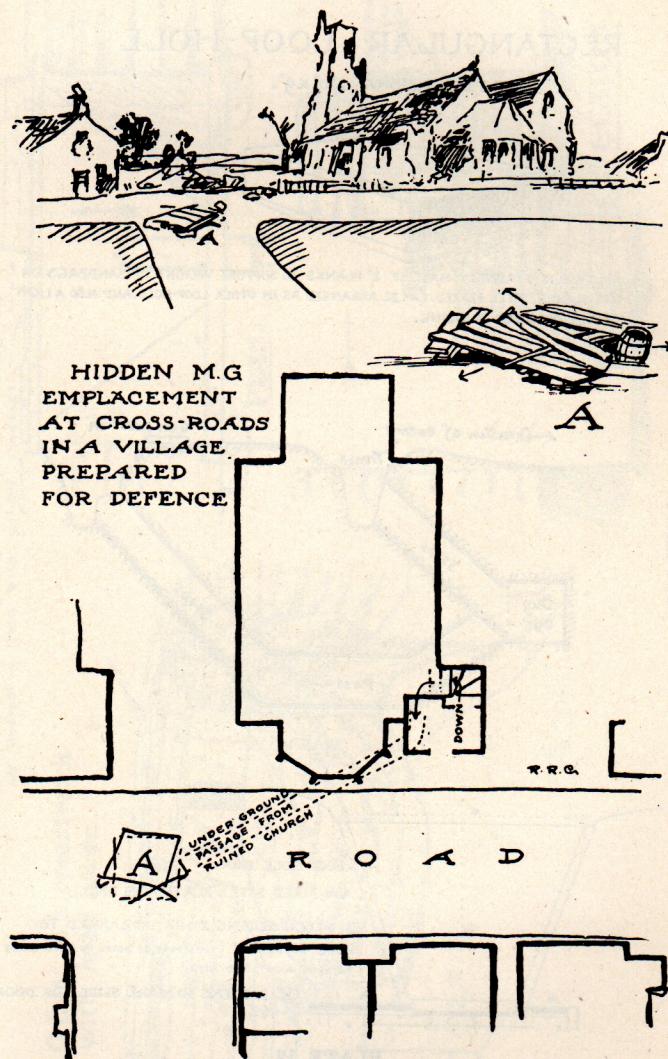
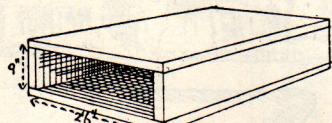


PLATE 11.

RECTANGULAR LOOP-HOLE.

INSIDE DIMENSIONS 2'6" x 9".



THIS IS STRONGLY MADE OF 2" PLANKS TO SUPPORT WEIGHT OF SANDBAGS ON TOP. SLIDING STEEL PLATES CAN BE ARRANGED AS IN OTHER LOOP-HOLE, AND ALSO A LIGHT HINGED DOOR FOR BLINDING.

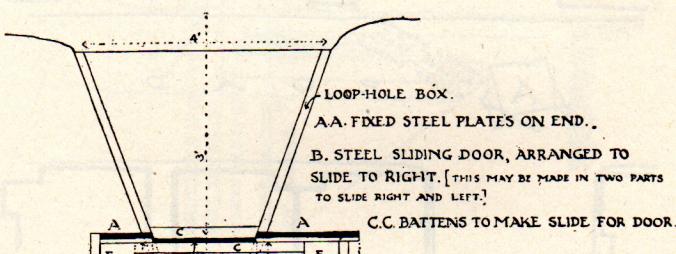
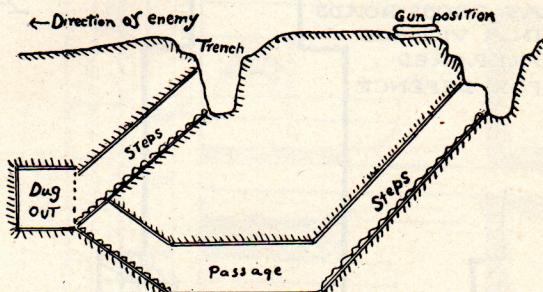
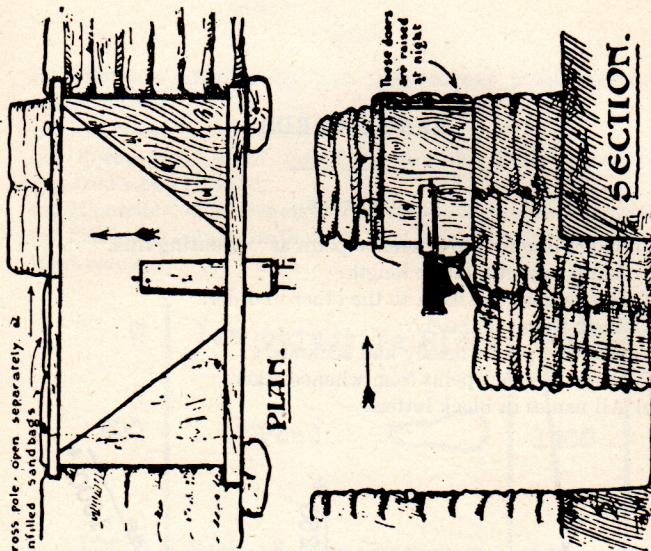


PLATE 12.



These two doors swing from cross pole, open separately & are covered in front with unfilled sandbags.

M.G. Empt in a breastwork with head cover.

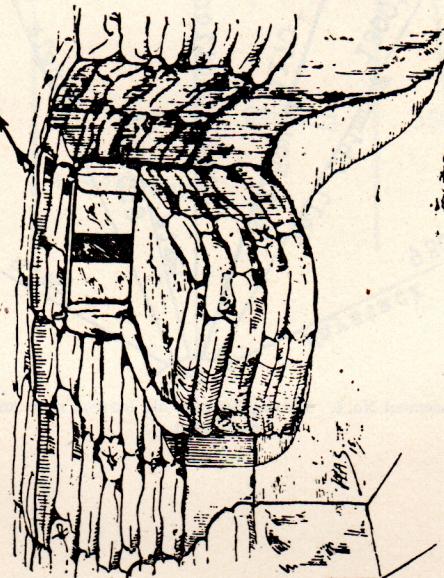
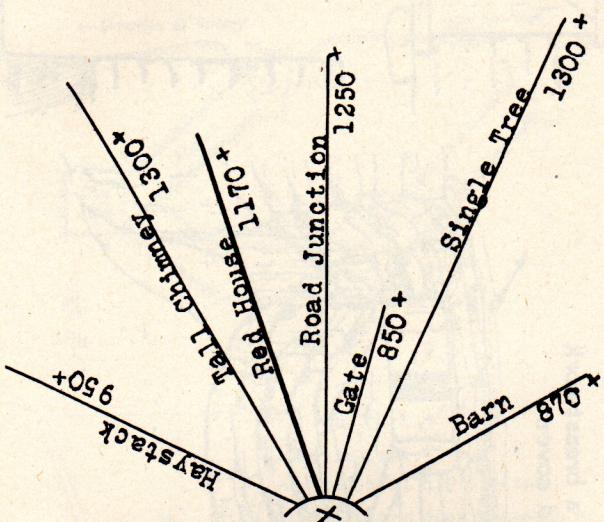


PLATE 13.

RANGE CARDS.

DEFENSE.

- (a) Thick line first to reference point as "orienting line."
- (b) Lines correct relative length.
- (c) Range from one flank to the other in order.
- (d) Mark lines accurately.
- (e) Describe points briefly and accurately.
- (f) Describe exact point from whence taken.
- (g) All names in block letters.



Emplacement No. 6. Midway between old barn on right and small tree on left.

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ATTACK.

- (a) First take range to objective, then halfway point, then intermediate objects.
- (b) Put ranges in right-hand column.
- (c) Objects must be in line of advance and likely to be easily recognized when reached.
- (d) If possible, objective should be visible from each point taken.
- (e) Fill in left column with range from objective and rule through right column.

0	1st objective Ridge	2000.
600	Pond	1400.-
1000	Row of trees	1000.
1450	Gate	550.
2000	Rendezvous.	0

PLATE 14.

The graticule card.

[To be held 18" from eye.]

FOR MARK VI AMMUNITION.

—200	300—
—400	500—
—600	700—
—800	900—
—1000	1100—
—1200	1300—
—1400	1500—
—1600	1700—
—1800	1900—
2000	2000

The machine gunner's range and trajectory card with angles of elevation etc., for Mark VI ammunition.

Range.	Approximate angles of elevation.	Rise in minutes.	Culminating point of trajectory in feet.
Yards.	° ′		
100	.. 10	..	...
200	.. 14	7	...
300	.. 21	6	1
400	.. 27	8	2
500	.. 35	9	3½
600	.. 44	13	6
700	.. 56	13	9
800	1 10	12	13
900	1 23	15	17½
1,000	1 38	15	23½
1,100	1 53	16	31½
1,200	2 11	18	41
1,300	2 28	20	52
1,400	2 49	20	66
1,500	3 9	21	82
1,600	3 30	25	100
1,700	3 55	25	122
1,800	4 22	28	146
1,900	4 50	29	174
2,000	5 20	32	206
2,100	5 53	37	241
2,200	6 29	38	282
2,300	7 11	47	325
2,400	7 57	47	374
2,500	8 46	52	429
2,600	9 39	55	489
2,700	10 37	59	558
2,800	11 37	62	637
2,900	12 41	..	...

Trajectory disks, illustrating the cone of fire as it will appear in overhead fire, etc., for Mark VI ammunition.

Range.	Diameter of disks.		Height of center of disk above ground, muzzle of gun is taken as being 20 inches above ground.		
	75 per cent cone.	100 per cent cone.	700 yards trajectory.	800 yards trajectory.	900 yards trajectory.
Yards.	Ft. ins.	Ft. ins.	Ft. ins.	Ft. ins.	Ft. ins.
100	8½	2 0	5 5	6 5	8 8½
200	1 3½	3 6	8 6	10 6	12 10
300	2 0	5 0	10 2	13 4	16 10
400	2 8½	6 6	10 7	14 8	19 6
500	3 6	8 0	9 4	14 2	20 2
600	4 0	10 0	5 11	12 1	19 0
700	4 6	12 0	.. ..	7 6	15 6
800	5 6	14 0	.. ..	.. ..	9 1
1,000	6 8	16 0	.. ..	.. ..	.. ..
1,500	10 0	24 0	.. ..	.. ..	.. ..
2,000	13 4	32 0	.. ..	.. ..	.. ..

DEPTH OF ZONE BEATEN BY 75 PER CENT OF SHOTS FIRED FROM A MAXIM GUN.

Range.	Dispersion of cone.	
	Depth.	Width.
Yards.	Yards.	Feet.
500	150	4
1,000	70	8
1,500	60	13
2,000	50	19

PROBABLE ERRORS IN RANGING TO BE ALLOWED FOR WHEN DIRECTING FIRE.

Method of ranging.	Per cent of error.	Extent of ground to be searched to overcome probable errors in ranging.			
		500 yards.	1,000 yards.	1,500 yards.	2,000 yards.
Judging distance.....	15	Yards.	Yards.	Yards.	Yards.
Judging distance combined with "key ranges".....	10	150	300	450	600
Range-finding instruments.....	5	100	200	300	400
		50	100	150	200

The graticule card.

[To be held 18" from eye.]

FOR MARK VII AMMUNITION.

—200	300
—400	500
—600	700
—800	900
—1000	1100
—1200	1300
—1400	1500
—1600	1700
—1800	1900
	2000

Mark VII ammunition.

Angles of elevation.	Angle of descent.	Culminating point.	Trajectory disk.	Lowest shot			Height of center of disk above ground.		
				Vertical.	Horizontal.	100 per cent cone below center of disk.	700 yards.	800 yards.	900 yards.
° ' "	Feet.	' "	' "	' "	' "	' "	' "	' "	' "
100 yards....	12 5	.....	0 11	0 6	1 1	3 5	4 3	5 0	
200 yards....	15	.....	1 10	1 0	2 2	5 8	7 2	8 11	
300 yards....	18 5	.....	0 6	2 9	1 6	3 3	6 9	9 1	11 4
400 yards....	22 5	1 in 300	1 3	3 8	2 0	4 4	6 11	9 10	13 2
500 yards....	27	1 in 180	2 3	4 8	2 6	5 5	5 11	9 8	13 9
600 yards....	32 5	1 in 120	3 8	5 7	3 0	6 6	3 10	8 2	13 2
700 yards....	38 5	1 in 90	6 1	6 7	3 6	7 7	.....	5 1	10 10
800 yards....	46	1 in 67	8 9	7 6	4 0	8 8	.....	.....	6 7
900 yards....	54	1 in 50	12 8	.....	.....	.....	.....	.....	.....
1,000 yards....	1 3 5	1 in 40	17 8	.....	.....	.....	.....	.....	.....
1,100 yards....	1 14 5	1 in 30	24 1	.....	.....	.....	.....	.....	.....
1,200 yards....	1 27	1 in 24	32 4	.....	.....	.....	.....	.....	.....
1,300 yards....	1 41	1 in 20	42	.....	.....	.....	.....	.....	.....
1,400 yards....	1 57	1 in 15	54	At 100 yards.....	.....	2 9	.....	.....	.....
1,500 yards....	2 15	1 in 13	69	At 200 yards.....	.....	5 7	.....	.....	.....
1,600 yards....	2 35	1 in 11	87	At 300 yards.....	.....	7 6	.....	.....	.....
1,700 yards....	2 58	1 in 9	108	At 400 yards.....	.....	8 8	.....	.....	.....
1,800 yards....	3 23 5	1 in 8	132	At 500 yards.....	.....	8 9	.....	.....	.....
1,900 yards....	3 52	1 in 7	161	At 600 yards.....	.....	7 6	.....	.....	.....
2,000 yards....	4 24	1 in 6	195	At 700 yards.....	.....	4 8	.....	.....	.....
75% zones: 500 yards, $\frac{220}{2\frac{1}{2}}$ yds.; 1,000 yards, $\frac{140}{5}$ yds.; 1,500 yards, $\frac{70}{10}$ yds.									

Measurements of the 75 per cent cone, Mark VII ammunition.

Range.	Vertical diameter.	Horizontal diameter.	Depth of E. B. zone.
	Feet.	Feet.	Yards.
500	5	2 $\frac{1}{2}$	220
800	8	4	172
1,000	10	5	140
1,200	12	7	112
1,500	15	10	70

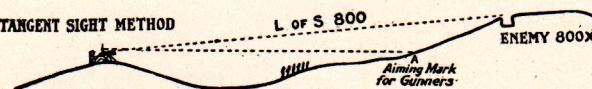
OVERHEAD FIRE.

(a) String and Card Method of Overhead Fire.



Safe to fire overhead until troops reach "A."

(b) TANGENT SIGHT METHOD



Sight raised 400" to give safety angle of 30 minutes shown by dotted line.





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